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Equipment and Operating Procedures For an Automated Cleaning System In a Milk Processing Plant

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CONTENTS

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EQUIPMENT AND OPERATING PROCEDURES FOR AN AUTOMATED CLEANING SYSTEM IN A MILK PROCESSING PLANT

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SUMMARY

Engineers of the Transportation and Facilities Research Division, Agricultural Research Service, at Columbia, Mo., in cooperation with food scientists of the Department of Food Science and Nutrition, Missouri Agricultural Experiment Station, designed and installed the automated cleaning system now used in the University of Missouri dairy plant. The automated cleaning system was designed to minimize the equipment used, reduce labor requirements for cleaning, and meet Federal, State, and local regulations regarding installation and operation.

A detailed explanation of the operation of the automated cleaning system is given to provide guidelines for plant managers concerned with replacement or modification of their present cleaning systems. Wiring diagrams are provided, where applicable, to assist dairy plant engineers in evaluating the system.

The cost of the equipment was $7,190 and installation cost was $3,000, for a total cost of $10,190. Ownership and operating costs of the equipment were estimated at $33.14 per week. A chart is presented that allows a plant manager, using the wage scale in his plant, to determine how much labor the automated cleaning system must eliminate to make it advantageous to his particular case.

INTRODUCTION

Cleaning is an essential part of any fluid-milk processing operation. With the increasing price competition from other products in the consumer's market, milk processing costs must be held to a minimum. Cleaning of storage tanks and processing equipment is a substantial part of the plant's processing costs. To obtain maximum efficiency from CIP (cleaned-in-place) cleaning, the plant management and operators must understand the system they are using. If installation or modification of a CIP cleaning system is planned, information should be obtained regarding plant needs and equipment available. This information should then be used to obtain a CIP cleaning system that will operate at minimum cost. If the automated CIP system is properly selected, installed, and

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programed so that its initial performance is satisfactory, the equipment will continue to clean adequately in all probability, provided it is properly maintained.

Engineers of the Transportation and Facilities Research Division at Columbia, Mo., in cooperation with food scientists of the Department of Food Science and Nutrition of the Missouri Agricultural Experiment Station, designed and installed the cleaning system now used in the University of Missouri dairy plant. The purpose of this report is to explain the operation of the cleaning system and to provide guidelines for plant managers regarding replacement or modification of their present cleaning systems.

DESCRIPTION OF UNITS

The automated CIP cleaning system is composed of several electromechanical units, each designed to perform a specific operation. A unit consists of several mechanical and electrical components. Components must be chosen to suit the operation to be performed, and they must be mutually compatible. Each unit is designed to make the complete CIP cleaning system as versatile as possible. An automated cleaning system has two basic units--controlling and operating.

Controlling Units

A controlling unit is defined as a unit containing one or more electrical components that energize and de-energize an operating unit.

The controlling units sequence and time the cleaning and sanitizing cycles. They provide for continuity of day-to-day operation after the timers have been programed.

The nucleus of the controlling unit is a programed timer. The timer, with such accessories as selector switches and relays, controls the various operations of a cycle.

The components of a controlling unit for the CIP cleaning system are cam timers, three-position switches (hand--off--automatic), selector switches, relays, and indicator lights. The functions of these components are described below.

Cam Timers

Cam timers are used to control the units of the cleaning system and the equipment in the processing line during the cleaning cycle. They are programed by varying the length of the raised part of each cam; this part of the cam positions the microswitch. Because each cam controls the on-off status of one operating unit, the number of cams on the timer must be at least as great as the number of operating units. Figure 1 is a schematic diagram of a microswitch on a cam timer that energizes a control relay. As the cam turns, it moves the microswitch's position arm to open or close the electrical circuit to the control relay.

Three-Position Switches

The three-position switch (fig. 2) allows the manual or automatic operation of a single operating unit in the system. These switches will henceforth

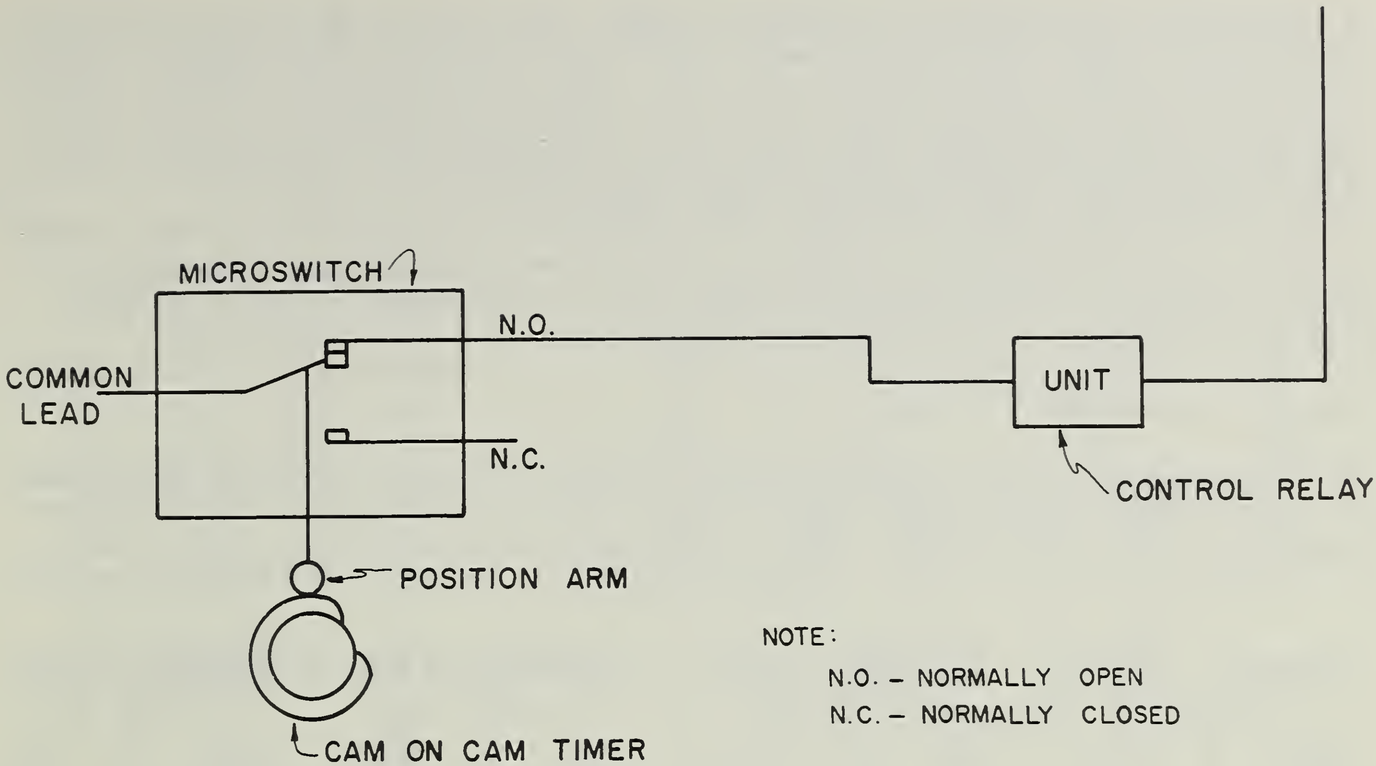

Figure 1.--Schematic diagram of a microswitch controlled by a cam on a cam timer.

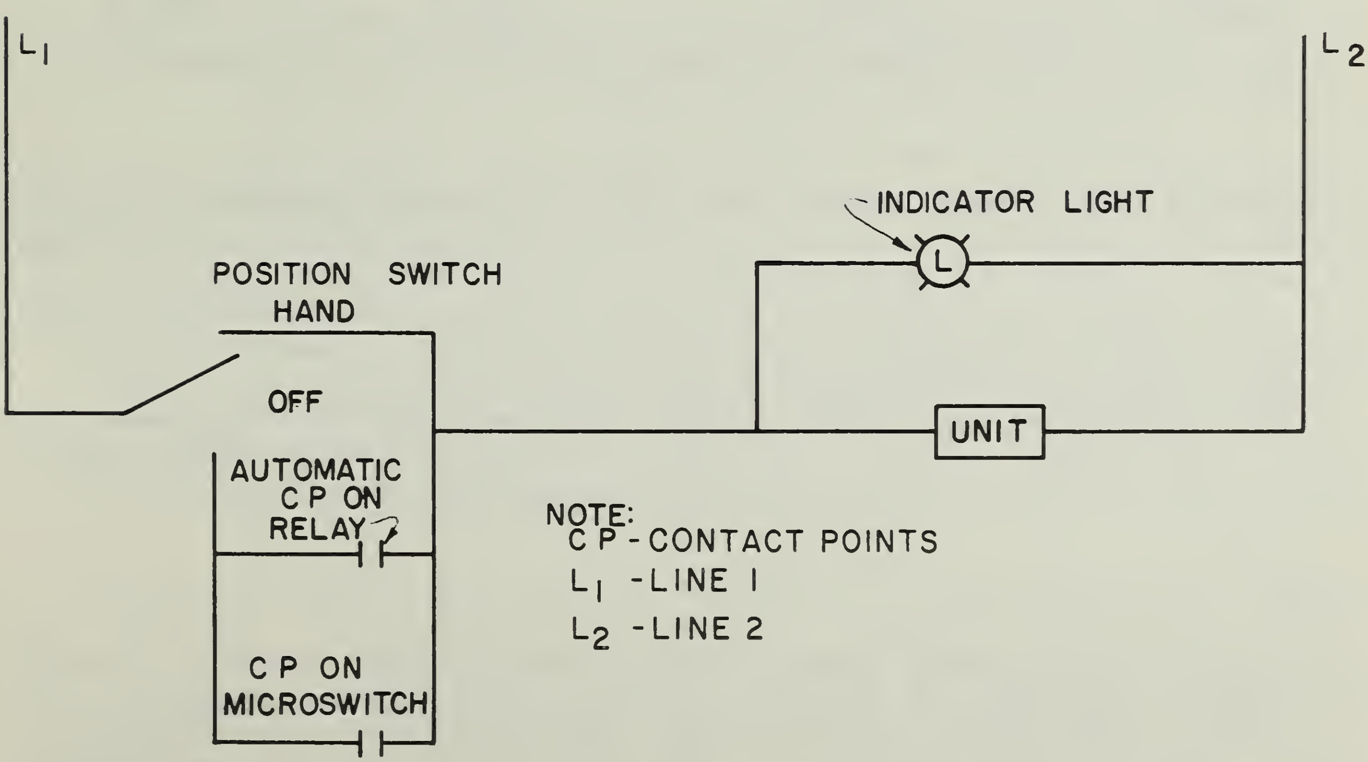

Figure 2.--Schematic diagram of a position switch used to control an electrical operating unit.

be referred to as "position switches." When the position switch is placed in the "hand" setting (the terms "hand" and "on" are used interchangeably), the attached operating unit and the indicator light are energized. If the switch is moved to the "automatic" setting, the circuit can be controlled by a relay or a microswitch, or both. Each time the operating unit (for example, the CIP pump) is energized, the indicator light comes on.

The circuitry (fig. 2) permits the cleaning system to be operated either manually or automatically, or with a combination of manual and automatic controls. If part of the automated system fails to function properly on the automatic setting, it can be operated manually.

Selector Switches

A multideck rotary switch (fig. 3) is used to select specific operations to be performed simultaneously by various pieces of equipment. Each deck of the rotary switch (hereafter called a "selector switch") has a common point--

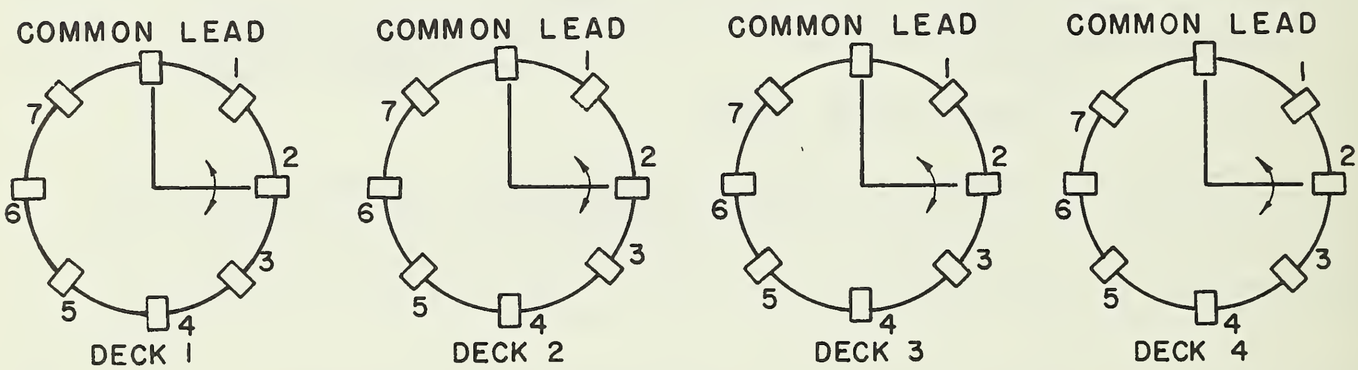

Figure 3.--Schematic diagram of a rotary switch with seven positions and four decks.

a connection for the power source. The common points for all decks may be connected to one power source, or each may have an individual power source. When the switch, as shown, is turned clockwise from the "off" position to position No. 2, for example, the electrical components connected to position No. 2 on all of the decks are energized, and current flows from the common point(s) through the switch and out through the No. 2 positions.

In the automated CIP cleaning system, the power source to the common point on the selector switch is connected to a position switch. Thus, the circuit can be selected and then energized either manually or automatically, as desired.

Relays

Relays in an automated system are used to direct flow of current to various pieces of equipment, to energize control circuits, and to prevent feedback.

A relay consists of a coil, a plunger with a position arm and spring, several contact points, and housing. When an electric current flows through the coil on the relay, the plunger located in the center of the coil changes positions. The position arm attached to the plunger forces the contact points

to open or close, according to the normal position of the points. The open position is generally referred to as "N.O." (normally open), and the closed position as "N.C." (normally closed).

In the automated controlling units for the CIP cleaning system described in this report, two general types of relays were used--industrial and plug-in (fig. 4). The industrial relays are used in control circuits that require more

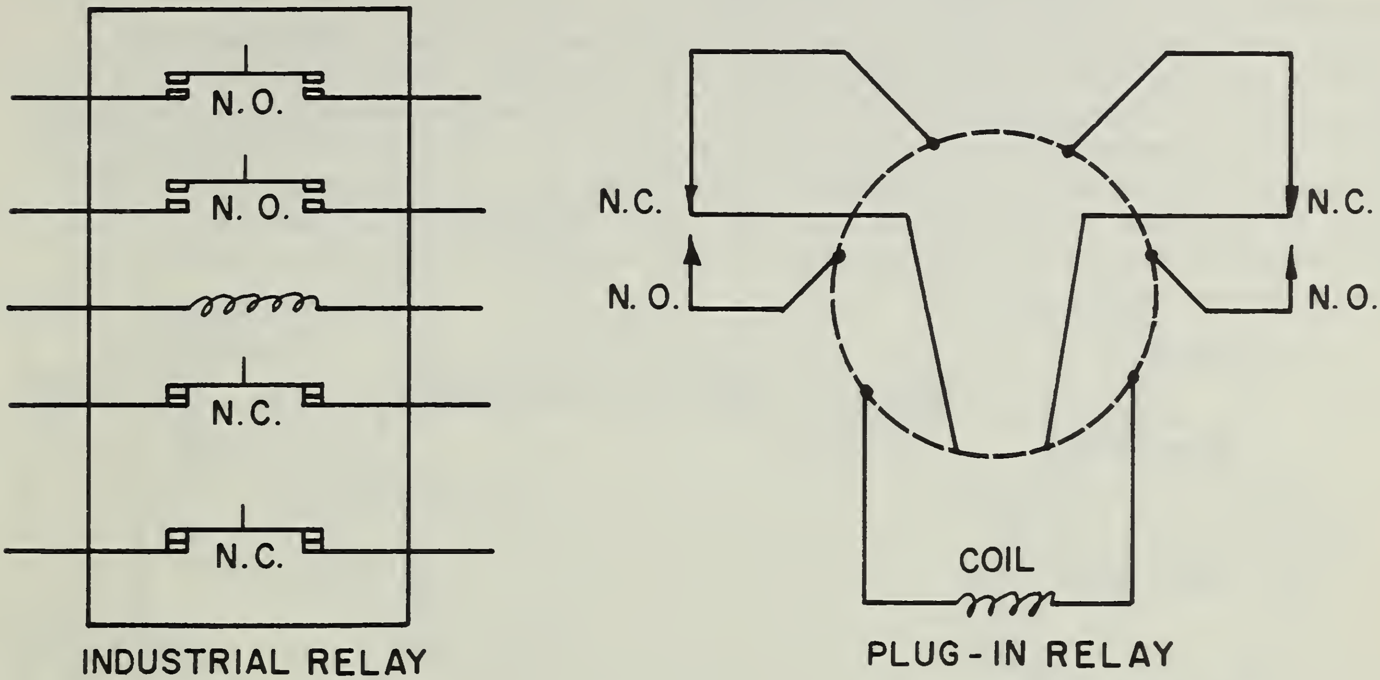

Figure 4.--Schematic diagram of two types of relays commonly used in electrical control systems.

than three contact points, and in power circuits. The plug-in relays are used in control circuits that need three or fewer contact points, and to prevent feedback.

Indicator Lights

Indicator lights are used in the CIP cleaning circuits to indicate when units are operating (fig. 2). The indicator light and the unit are wired in parallel sequence.

Accessory Controlling Units

During a cleaning cycle, several operations must be performed by units other than those described above. These units supplement the cleaning cycle by opening and closing valves and by starting and stopping pieces of equipment in the processing line to allow adequate cleaning. The accessory circuits are controlled by cams on the cam timers; for example, one cam is set to start and stop the homogenizer during different phases of the cleaning cycle so that it can be cleaned in place.

For proper cleaning, an air-actuated valve in the processing system must be pulsed during the cleaning cycle. "Pulsing the valve" can be defined as the moving of the valve stem back and forth in the valve chamber. When the valve is pulsed, cleaning solution flows around the stem and valve seat and cleans them. Either intermittent or continuous pulsing of individual valves may be necessary, according to the system design.

One method of pulsing is the "break-the-electrical-circuit" method. With this method, a pulsing unit consisting of a timer with a single cam is used to break the electrical circuit to the valve(s) to be pulsed. Each selector switch setting also selects the valve(s) to be pulsed during the cleaning cycle. Selection is accomplished by wiring the circuit for the valves to be pulsed to each switch setting across decks 4 and 5 (fig. 5). When the pulsing unit is energized during the cleaning cycle, the valve circuit is momentarily broken once during each revolution of the cam. The length of time that the circuit is de-energized during pulsing determines the movement of the valve stem in the air-actuated valve.

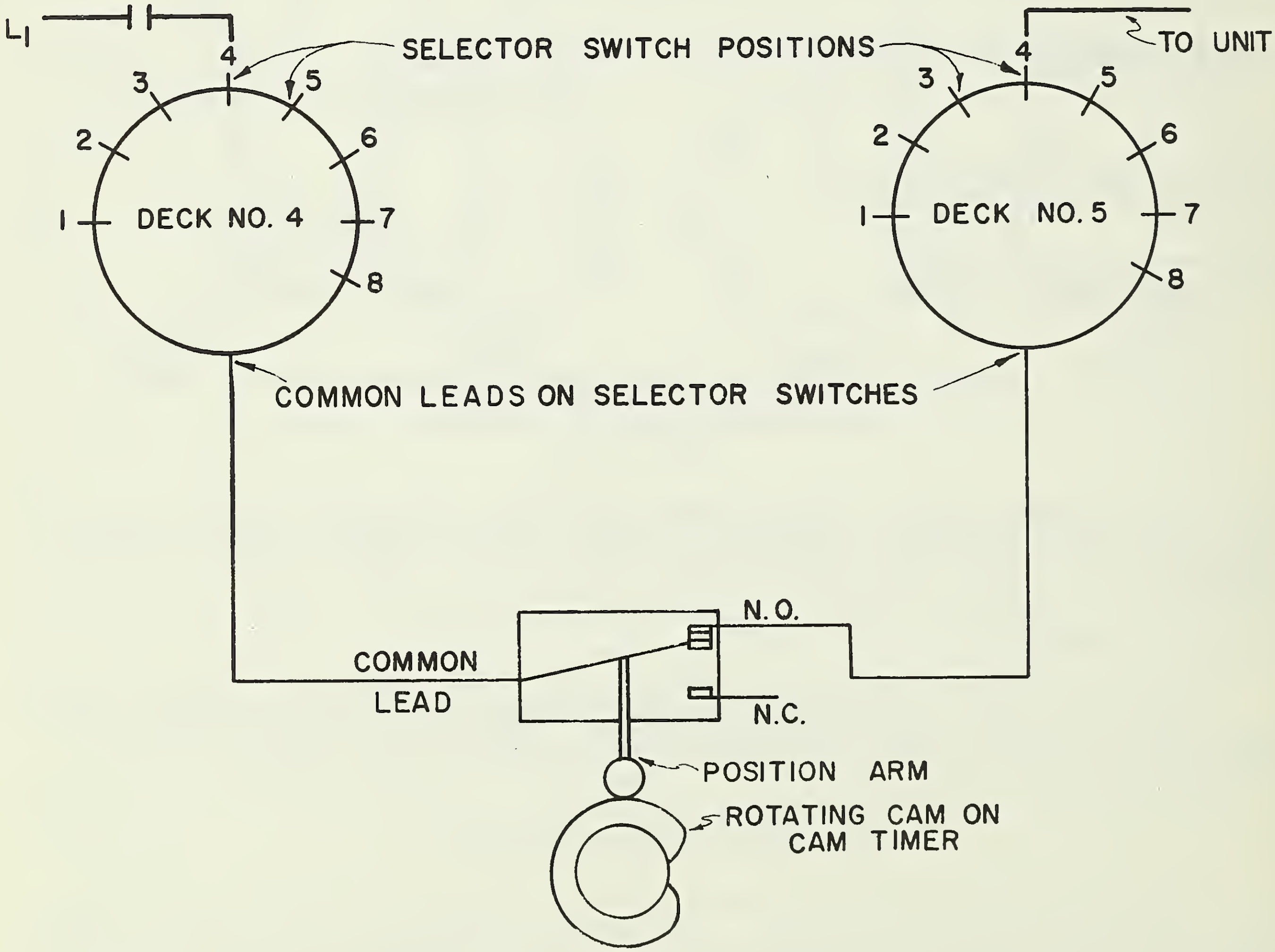

Figure 5.--Schematic diagram of valve-pulsing circuit.

A second method of pulsing, the "break-the-air" method, involves not only a pulsing unit consisting of the previously described single-cam timer but also a normally open solenoid air valve (fig. 6). The solenoid-operated air valve

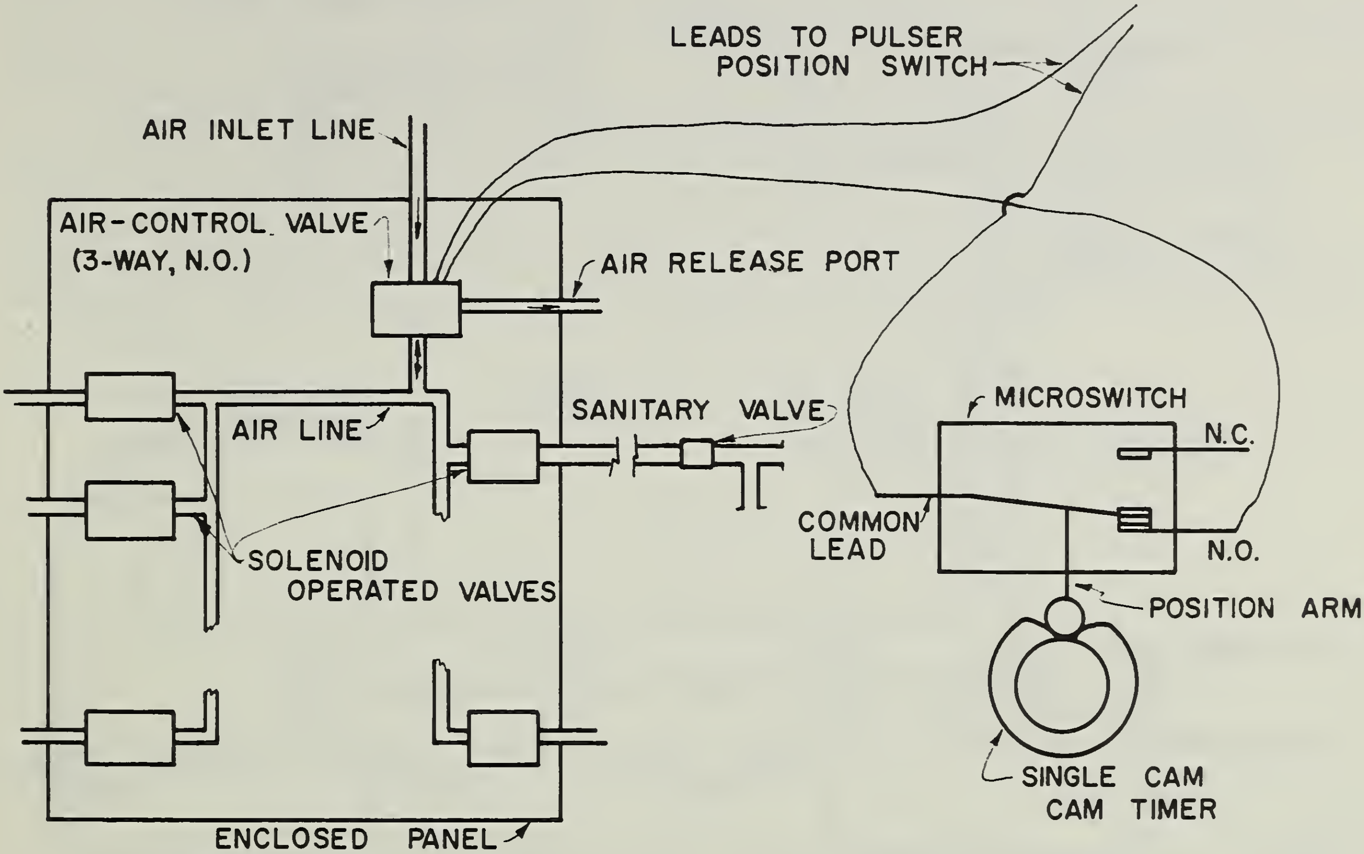

Figure 6.--Schematic diagram of "break-the-air" method for pulsing the air-actuated valves in front of the pasteurized milk tanks.

(hereafter called an "air control valve") is connected to the air inlet line and controls the supply of pressurized air to a manifold of solenoid-operated air valves. These valves, in turn, control sanitary valves that are to be pulsed during the cleaning cycle. The sanitary valves are initially opened by pressurized air. The valves move toward the closed position when air is released to the atmosphere through a release port on the air control valve. Alternate opening and closing of the air control valve by a cam timer results in pulsing of the sanitary valves. The amount of valve stem movement accords with the time the air release port is left open.

The two pulsing units can be controlled automatically by a cam timer in the CIP cleaning circuit or manually by position switches.

Operating Units

An operating unit is defined as one item of equipment, with its related components, that performs a specific function during the cleaning cycle.

The solution supply tank assembly, constructed of stainless steel, contains three compartments--rinse water (also used for making up the sanitizing solution), acid cleaning solution, and alkaline cleaning solution.

Figure 7 is a schematic diagram of the cleaning solution supply tank assembly, CIP pump, air-actuated valves, and the air blowdown valve.

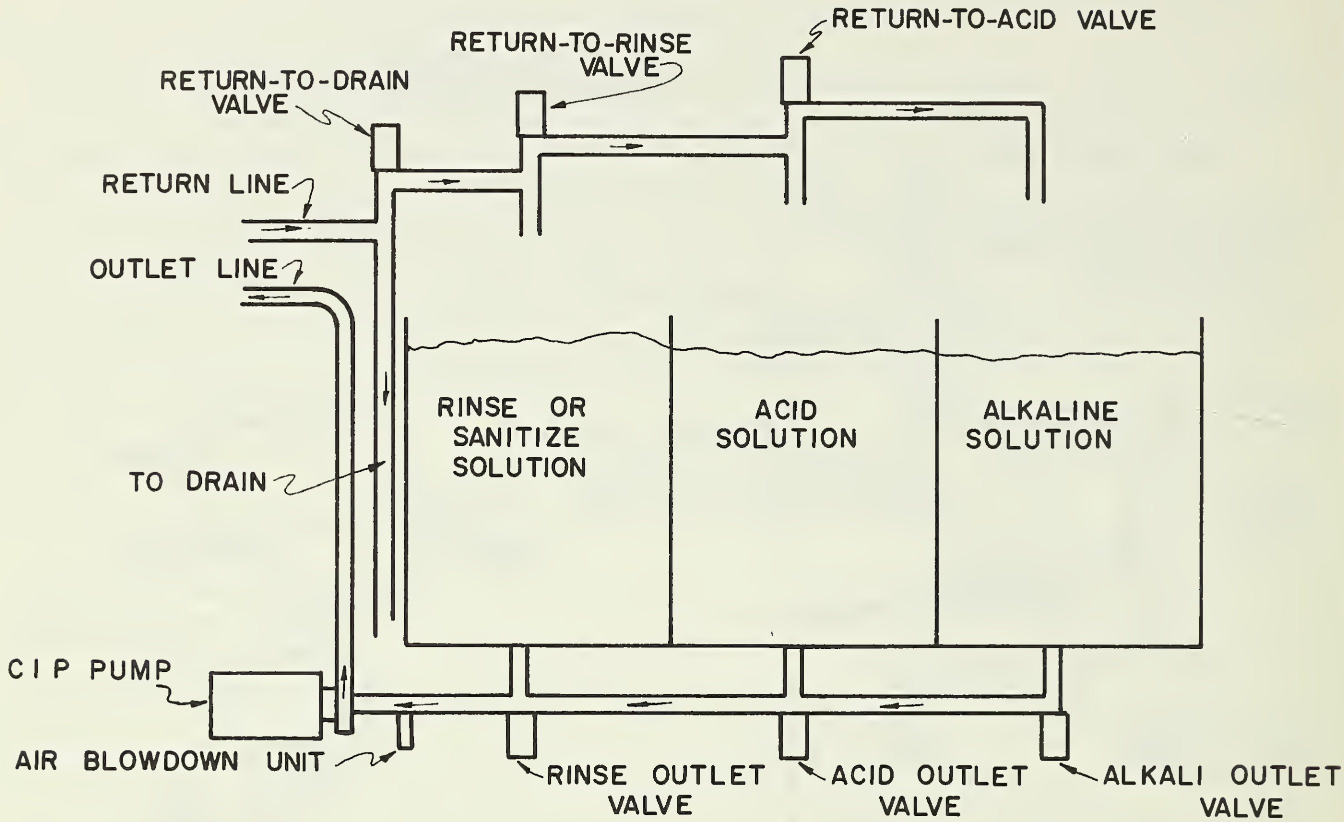

Figure 7.--Schematic diagram of CIP supply tank assembly, CIP pump, air-actuated valves, and air blowdown valve unit.

In each tank (compartment), automatic control is provided for: (1) volume of water, (2) cleaning solution temperature, and (3) detergent concentration.

CIP Pump Unit

In an automated CIP cleaning system, the cleaning solution must be moved from the supply tank assembly to the equipment being cleaned, and back to the tank. This movement requires two centrifugal pumps--one (the CIP pump) to move the solution through the equipment, and another (the CIP return pump) to return the solution to the tank assembly.

Each pump unit contains two components--a motor starter and a centrifugal pump.

Air-Actuated Valve Unit

Automated processing and cleaning are made possible by the availability of remotely controllable air-actuated valves. The air-actuated valves used in a milk processing plant are classified into two types: Sanitary and chemical. The valve and valve body of both types are constructed of stainless steel. The finish, design, and operation of the sanitary valve must meet 3-A Sanitary

Standards. (A 3-A Sanitary Standard for Dairy Equipment is a voluntary standard, developed by conferees representing sanitarians, equipment fabricators, dairy processors, and the U.S. Public Health Service. It covers features of sanitary design for an indicated item of dairy machinery or process.) Sanitary valves are used to direct the flow of milk in the plant. Chemical valves, which are used solely in the control of cleaning solution flow, do not possess as smooth a finish as that of the sanitary valves and are not required to meet 3-A Sanitary Standards.

Components of the valve unit for a cleaning solution tank assembly are an air-actuated chemical valve, and an electrically operated solenoid valve designed to control the flow of the pressurized air. Two types of chemical valves--shutoff and divert--are used on the solution supply tank assembly (fig. 8). The shutoff valves are used to release the rinse water or cleaning solutions. Divert valves are used to direct the flow of the returning cleaning solutions.

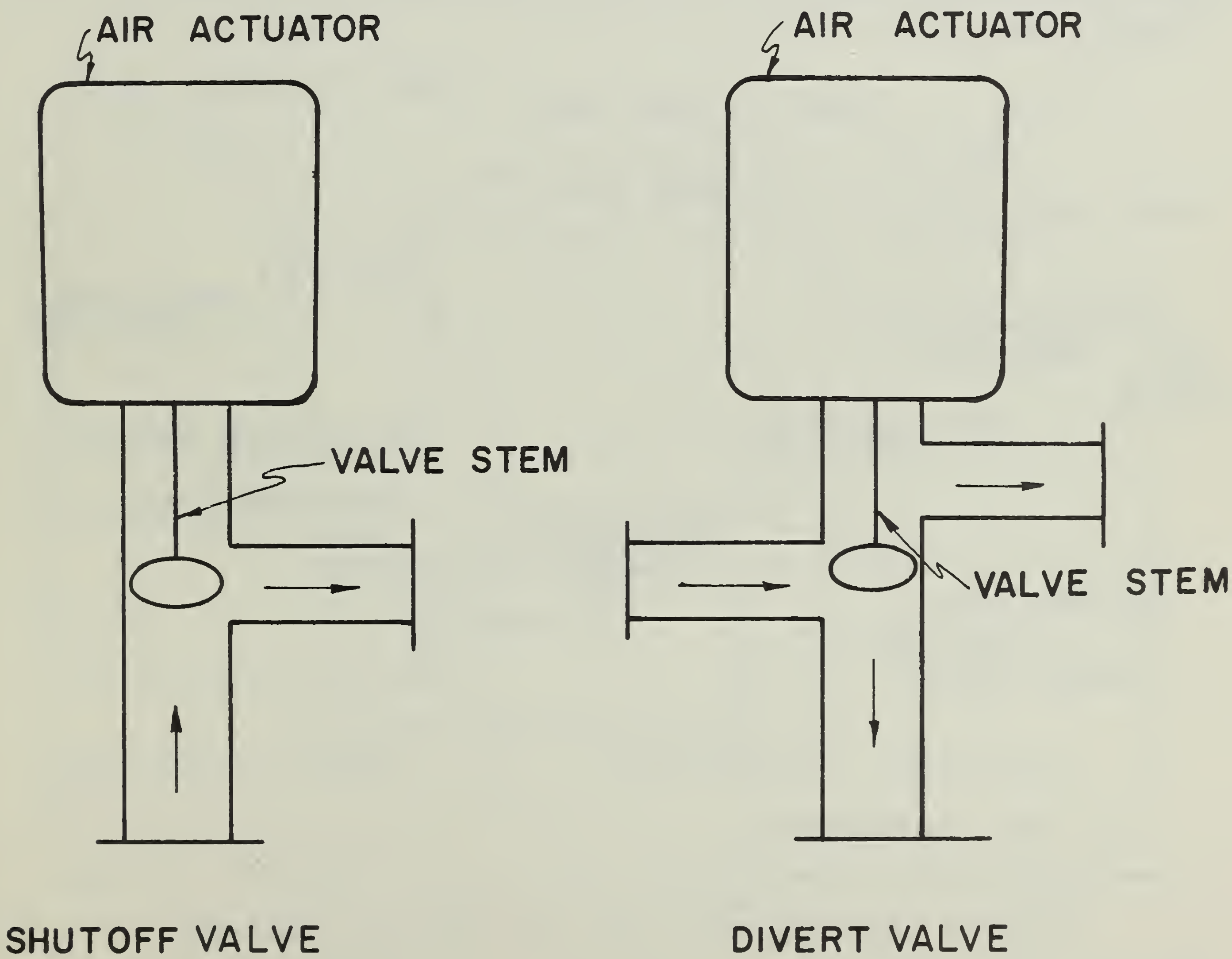

Figure 8.--Two types of air-actuated stainless steel valves used on CIP solution supply tank assembly (arrows indicate direction of solution flow).

Each valve unit is controlled by a position switch. Before an automatic cleaning cycle is started, the position switches for all the valve units involved in the cycle must be turned to the "automatic" setting. During the cycle, the programed cam timers energize and de-energize the solenoid valves that control the air-actuated valves so that the flow of cleaning solution or rinse water is accomplished at specified times. When the solenoid valve is energized, it opens and allows air to flow into the actuator. The compressed air forces the valve to change position; for example, a normally closed valve is opened.

Valves are held in normal position by spring tension. Air pressure used to change position approximates 35 to 50 pounds per square inch (p.s.i).

Solution Makeup Unit

A separate solution makeup unit controls the amount of water metered into each tank compartment of the solution supply tank assembly. The components of the solution makeup units are a solenoid operated water valve and a water level controller (fig. 9).

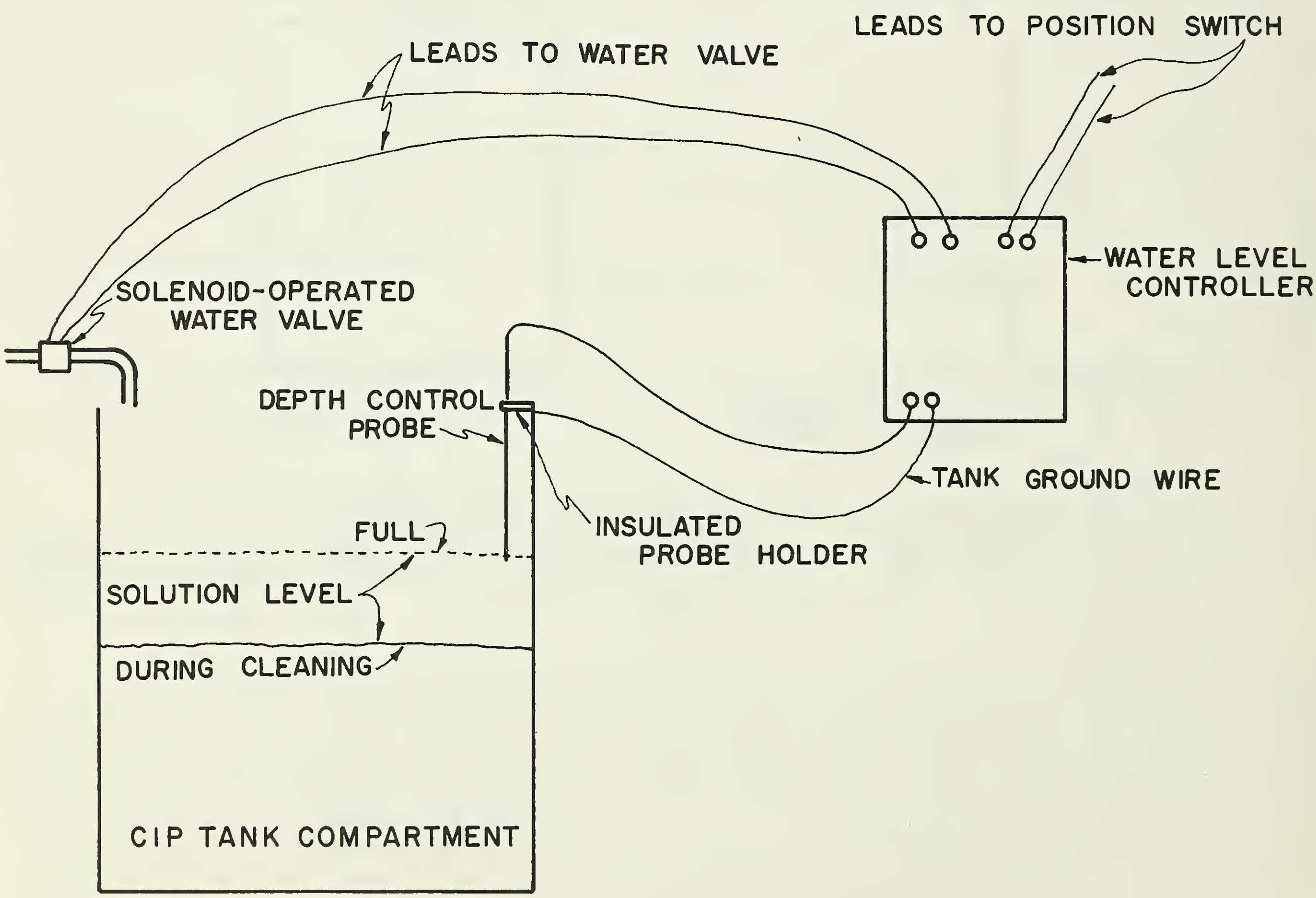

Figure 9.--Solution makeup unit for a CIP tank compartment.

The makeup unit can be either manually or automatically controlled from a position switch. The water level controller is connected to an adjustable depth control probe. When the unit is energized, the water valve is open until

solution touches the probe. Contact of the solution and probe completes a circuit, and the level controller responds by closing the solenoid-activated water valve. The volume of solution in the tank is changed by adjusting the height of the probe.

Solution Temperature Control Unit

Temperature control of the water or cleaning solution in an automated CIP cleaning system is very important. The rinse water and cleaning solution must be heated to, and maintained at, a given temperature during the cleaning cycle to insure adequate cleaning.

The components of a temperature control unit are an air-operated steam valve, a steam diffuser, a solenoid-operated air valve, a pressure regulator, and a temperature sensor and controller (fig. 10).

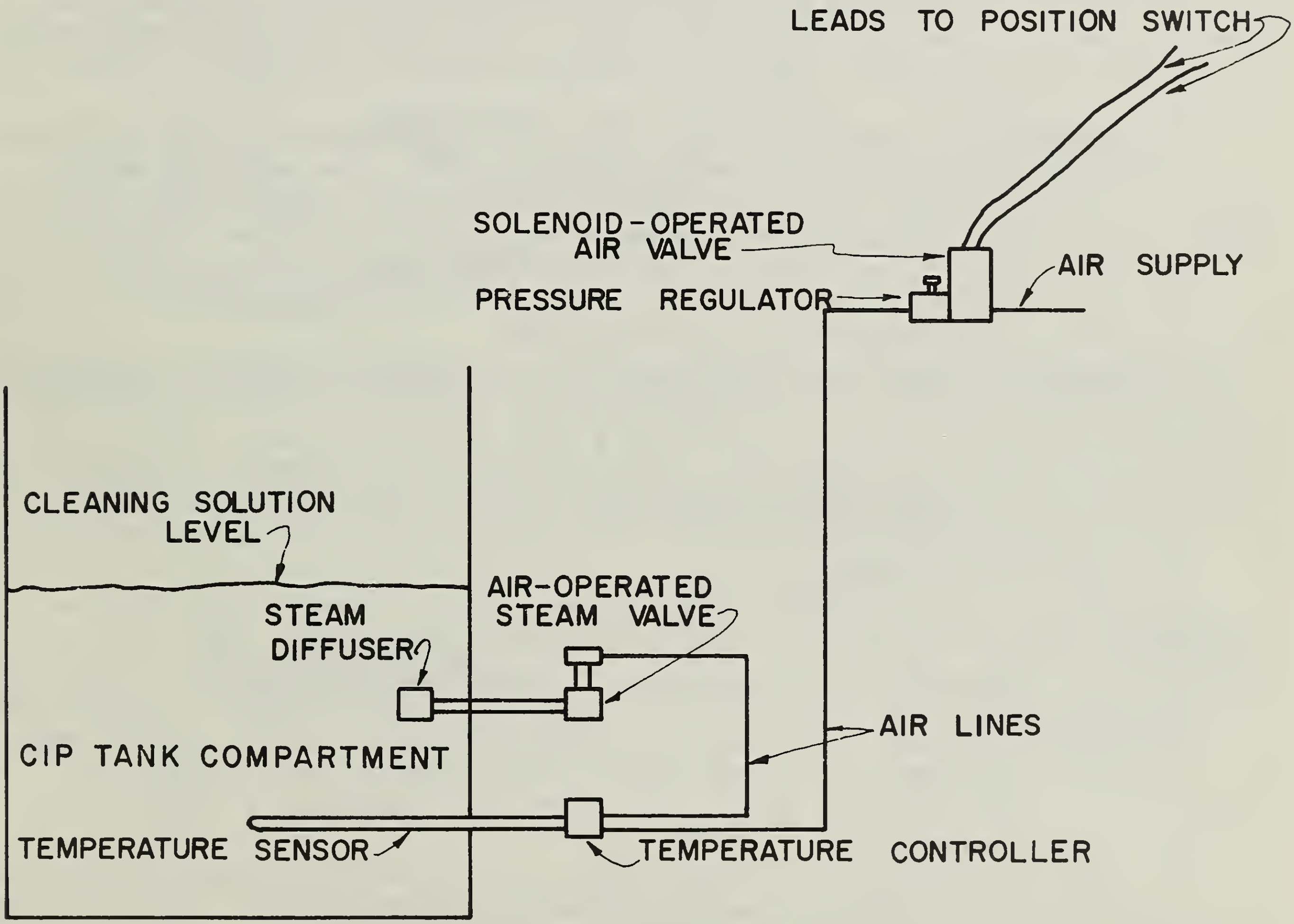

Figure 10.--Schematic diagram of the components of a solution temperature control unit for a CIP tank.

The air valve supplies air to the temperature controller, which, in turn, uses the air to open the steam valve when the solution in the tank is below the preset temperature. The pressure regulator reduces the air pressure to the level required by the temperature controller and the steam valve. The air-operated steam valve regulates the amount of steam entering the tank. The

diffuser mixes the steam and water and reduces the noise of the steam entering the water. The temperature control unit can be operated either manually or automatically. The desired temperature for the cleaning solution is set manually on a dial located on the temperature controller.

During the automatic cleaning cycle, a solenoid-operated air valve is energized, allowing air to pass to the temperature controller. If the solution temperature is below that set on the controller, air passes to the steam valve and opens it. The steam then flows through the valve into the steam diffuser and into the solution. When the solution reaches the predetermined temperature, the controller shuts off the air supply and allows the steam valve to close by spring action.

Detergent Metering Unit

Constant and adequate maintenance of detergent solution strength is an important part of automated cleaning. A predetermined amount of detergent should be added automatically to the water in the alkali and acid tanks before the solution is circulated, and more detergent should be added as the solution's strength is dissipated.

Metering devices may provide for addition of detergents either in proportion to, or independent of, the amount of water used. The metering device described in this report added detergent independently. Electrical conductivity of the cleaning solution is used to determine the amount of detergent that will be added automatically to each solution tank.

The unit consists of a conductivity controller and a metering device that may be either a liquid-feed or a dry-feed type.

Components of the liquid metering unit are a positive pump, a control relay (used to keep control and power circuits separate), and a conductivity controller with probes (fig. 11). Such a unit is used to feed liquid-acid detergent into the acid compartment of the supply tank assembly. Whenever the conductivity of the solution is below that desired, the controller energizes the control relay; this action starts the positive pump, and acid detergent is fed into the tank compartment.

An overflow type of feeder (fig. 12) is used to dispense dry-alkaline detergent. Dry detergent is placed in the feeder reservoir. The control system allows water to pass through this reservoir when the conductivity of the cleaning solution is less than that required. The detergent dissolves and the water carries it out through the overflow pipe and into the alkali tank. The conductivity controller is the same as that used for the liquid-feed system, but in the dry-feed system, the controller energizes a solenoid to operate a water valve.

The proper setting of the conductivity controller is determined by adding water to the tank, heating the water to the desired temperature, and manually adding the amount of alkaline detergent suggested by the detergent manufacturer. The screw on the controller is adjusted until it just shuts off the metering device. Changes in temperature of solution or in type of detergent will require changes in the controller setting.

The stainless steel probes of the conductivity controllers should be cleaned regularly to overcome corrosion and mineral deposits that reduce the probes' sensitivity and effectiveness.

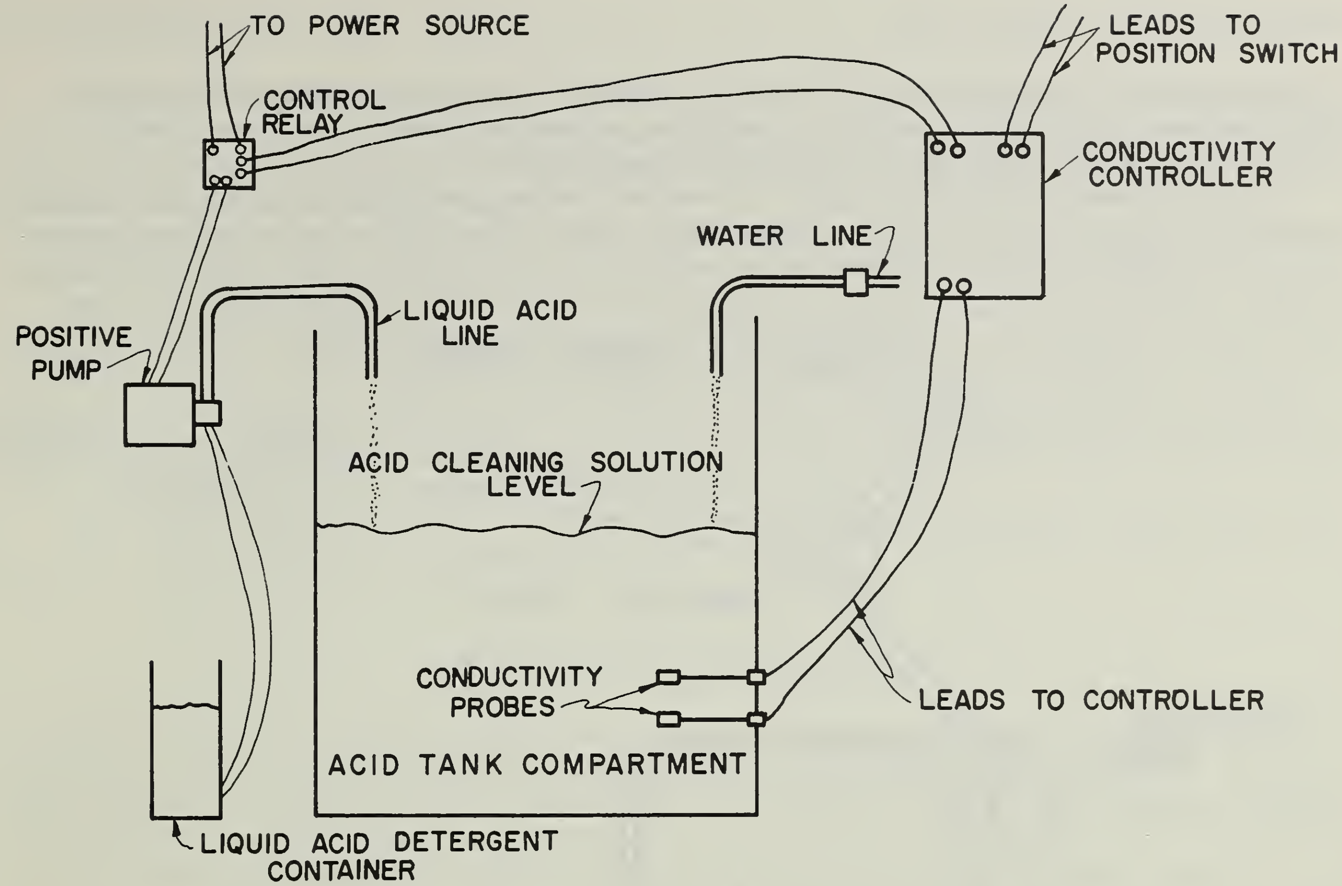

Figure 11.--Schematic diagram of the components of a liquid-acid feeder unit for a CIP tank.

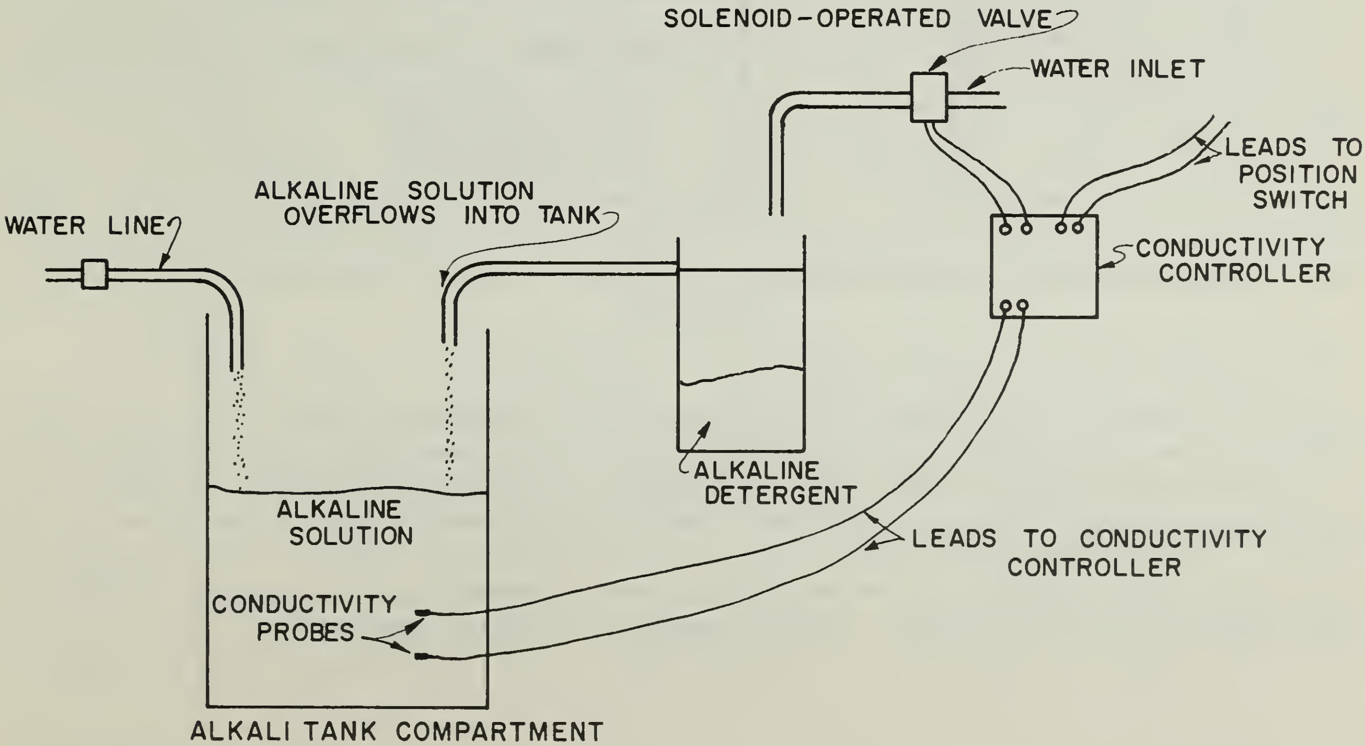

Figure 12.--Schematic diagram of the components of an overflow type of feeder unit for dry alkali

Liquid-Chlorine Feeder Unit

During the sanitize cycle of an automated system, chlorine is usually added volumetrically by use of a positive metering pump. The sanitizing solution is made up in the rinse tank compartment.

The components of the liquid-chlorine feeder unit are a control relay and a corrosion-resistant positive pump (fig. 13). The unit can be operated manually or automatically. At the beginning of the sanitize cycle, the position switch for the chlorine unit is placed in the "automatic" setting. A cam on the programed cam timer closes a microswitch that energizes the control relay in the chlorine feeder unit. The energized relay allows current to flow to the positive pump for the length of time that the cam keeps the microswitch closed. Liquid chlorine is pumped into the rinse and sanitize tank compartment during this period. The metering time is based on the capacity of the pump, the chlorine strength, and the amount of water involved.

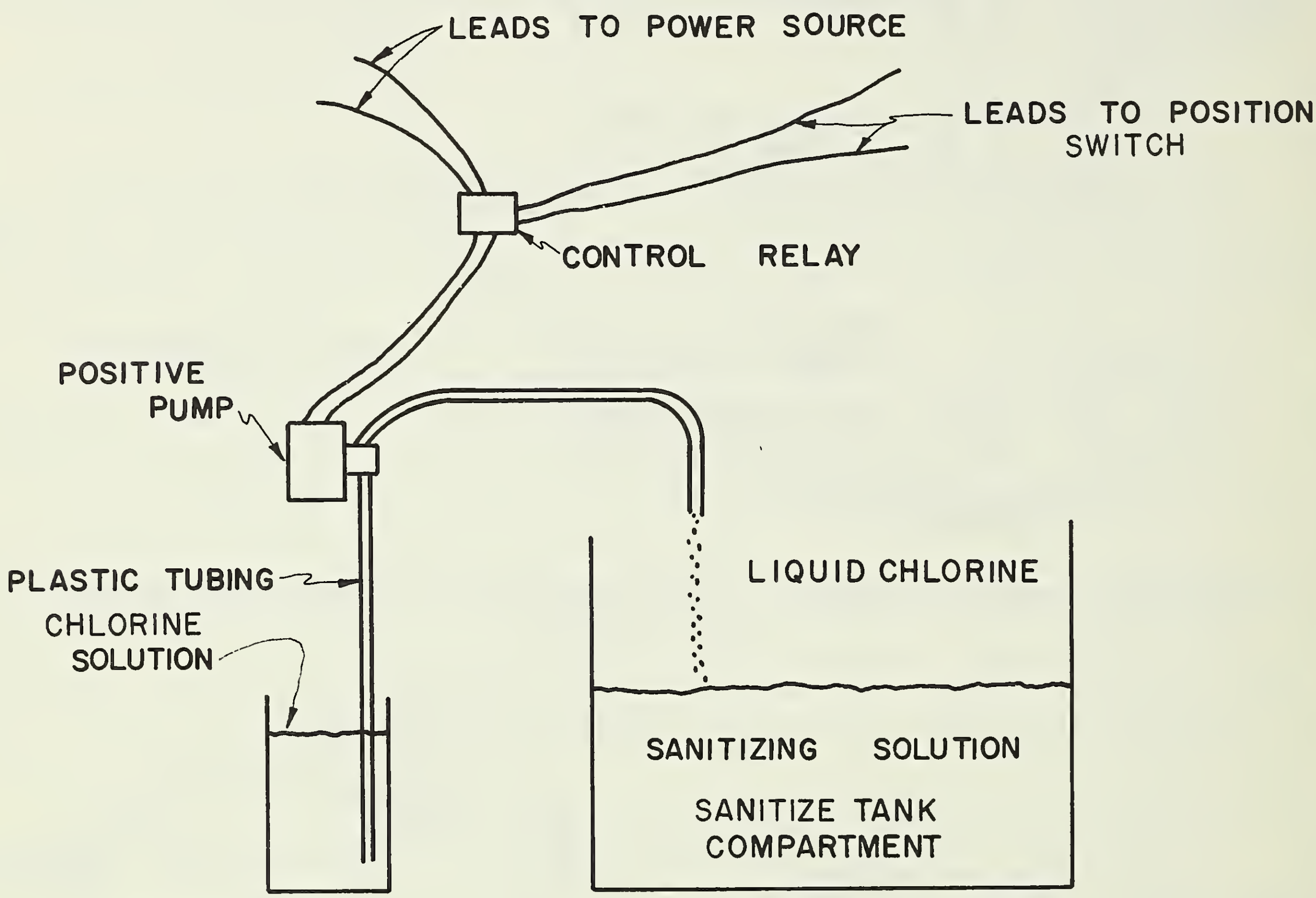

Figure 13.--Schematic diagram of the components of a feeder unit for liquid chlorine.

Air Blowdown Unit

The air blowdown unit is used to force the rinse water or cleaning solution from the tank outlet line. This procedure reduces the chance of different types of cleaning solutions becoming mixed, or of a cleaning solution's becoming mixed with rinse water.

The components of an air blowdown unit are a check valve (fig. 7) and a solenoid-operated valve.

The air blowdown unit is controlled by a position switch and cam; therefore, it can be operated either manually or automatically. When the unit is in automatic use, the cam controlling the air blowdown unit closes a microswitch at the end of each cleaning phase. By closing, the microswitch energizes a solenoid-operated valve. This valve opens and air flows into the pipe line, forcing the water or solution from the line.

The check valve prevents rinse water or cleaning solution from entering the air line during the cleaning cycle.

DESCRIPTION OF OPERATIONS

The plant's cleaning operation includes three automated cleaning cycles--sanitize, tank cleaning, and processing-line cleaning. Once started, each cycle operates automatically. Each cleaning cycle consists of several phases: Rinse, alkaline cleaning, and so forth.

The sanitize cycle is used to flush the processing equipment with a sanitizing solution before the processing operation is started.

The tank cleaning cycle is used to clean the raw and pasteurized milk storage tanks.

The processing-line cleaning cycle is used to clean the milk line in front of the raw milk tanks; the milk processing lines and equipment, including the homogenizer and flow-diversion valve;[2] the line in front of the pasteurized milk tanks; and the line to the Pure-Pak machine and bag filler.

An operator activates the cleaning cycle by pushing the appropriate start switch for the cycle. The start switch, which energizes the cam timer motors, must be held in until the cam that will control the cycle rotates enough to close the points on the controlling microswitch. This safety feature prevents the system from being started accidentally. At completion of the cycle, the controlling microswitch contact points are opened and the cam timer motors are de-energized.

A cleaning cycle can be stopped at any time if the cleaning cycle position switch is turned to the "off" setting. This action stops the cam timer, but the equipment in operation at the time continues to function. When the position switch is returned to "on," the cleaning cycle will resume. The cleaning cycle can be lengthened during the cleaning operation with this procedure. However, the cycle can be shortened only by the reprograming of the cam timers.

2/ Anderson, M. E., Webb, T. F., Marshall, R. T., and Shelley, D. S. Adapting the Flow-Diversion Valve and Homogenizer to Permit Automated Cleaning-in-Place of Milk Processing Lines. ARS 52-31, 18 pp., illus. 1969.

Sanitize Cycle

At the beginning of each day of processing, the milk lines and processing equipment are sanitized with a hypochlorite solution containing 150-200 parts per million (p.p.m.) available chlorine. The flow of sanitizing solution from the solution supply tank assembly to the 110-gallon batching tank is shown in figure 14.

In preparation for the sanitize cycle, the operator manually places divert assemblies Nos. 1 and 2 in the forward-flow position. The storage container for liquid chlorine is checked to insure that the chlorine is in adequate supply. As shown in figure 15, the following position switches on the panel are placed in the "automatic" setting: Rinse-tank solution makeup unit, chlorine feeder unit, valve control No. 1 unit, rinse-tank outlet valve unit, positive pump unit, CIP pump unit, valve pulser No. 1 unit, and air blowdown unit.

To activate the sanitize cycle, the operator moves the equipment-to-be-cleaned selector switch to the setting that allows the sanitizing solution to be directed into the milk line leading from the raw milk storage tanks to the milk processing equipment. The position switch for the equipment-to-be-cleaned selector switch is turned to the "automatic" setting. Next, the cleaning cycle selector switch is moved to setting No. 1 (the sanitize cycle setting) and the selector's position switch is moved to the "on" setting. Setting No. 1 activates the selection of cam timers that will perform the sanitizing operation. The start switch is then depressed to start the cycle. The sanitize cycle operational chart is shown in figure 16. Table 1 describes the function of each of the units used in this cycle.

The sanitize cycle has one phase only--the flushing of milk lines and processing equipment with a water-chlorine sanitizing solution. The cycle is composed of the following, in order of occurrence: As the cam timers rotate, two microswitches close, thus energizing the rinse-tank solution makeup unit and starting the chlorine pump. If the rinse tank is empty or only partly-full, the water level controller will open the water makeup valve so that the tank can be filled. When the water reaches the predetermined level, the water makeup valve is closed.

Next, the valves in front of the raw milk tanks are opened by the energizing of a control relay as the timer rotates. Before the CIP pump starts, the rinse-tank outlet valve is opened and the positive pump is started. Also, the rinse-tank water makeup unit and chlorine feeder unit are de-energized. When the CIP pump starts, the sanitizing solution is circulated through the outlet line, through divert assemblies Nos. 1 and 2, and into the milk line in front of the raw milk tanks. The sanitizing solution then flows through the positive pump and separator-clarifier and into the 110-gallon batching tank. The clarifier is not in operation during the sanitize cycle.

Approximately 12 minutes after the start of the cycle, the rinse-tank outlet valve closes and the CIP pump is stopped. This sequence prevents sanitizing solution from flowing back into the rinse tank. Then a cam energizes the pulsing circuit that causes the valves in the line to be pulsed. This procedure sanitizes the outlet ports on the valves. Next, the air blowdown unit is energized and air is admitted to force the sanitizing solution through the lines into the 110-gallon batching tank. The sanitizing solution is left in the 110-gallon tank until it is run through the processing equipment at the beginning of the processing cycle.

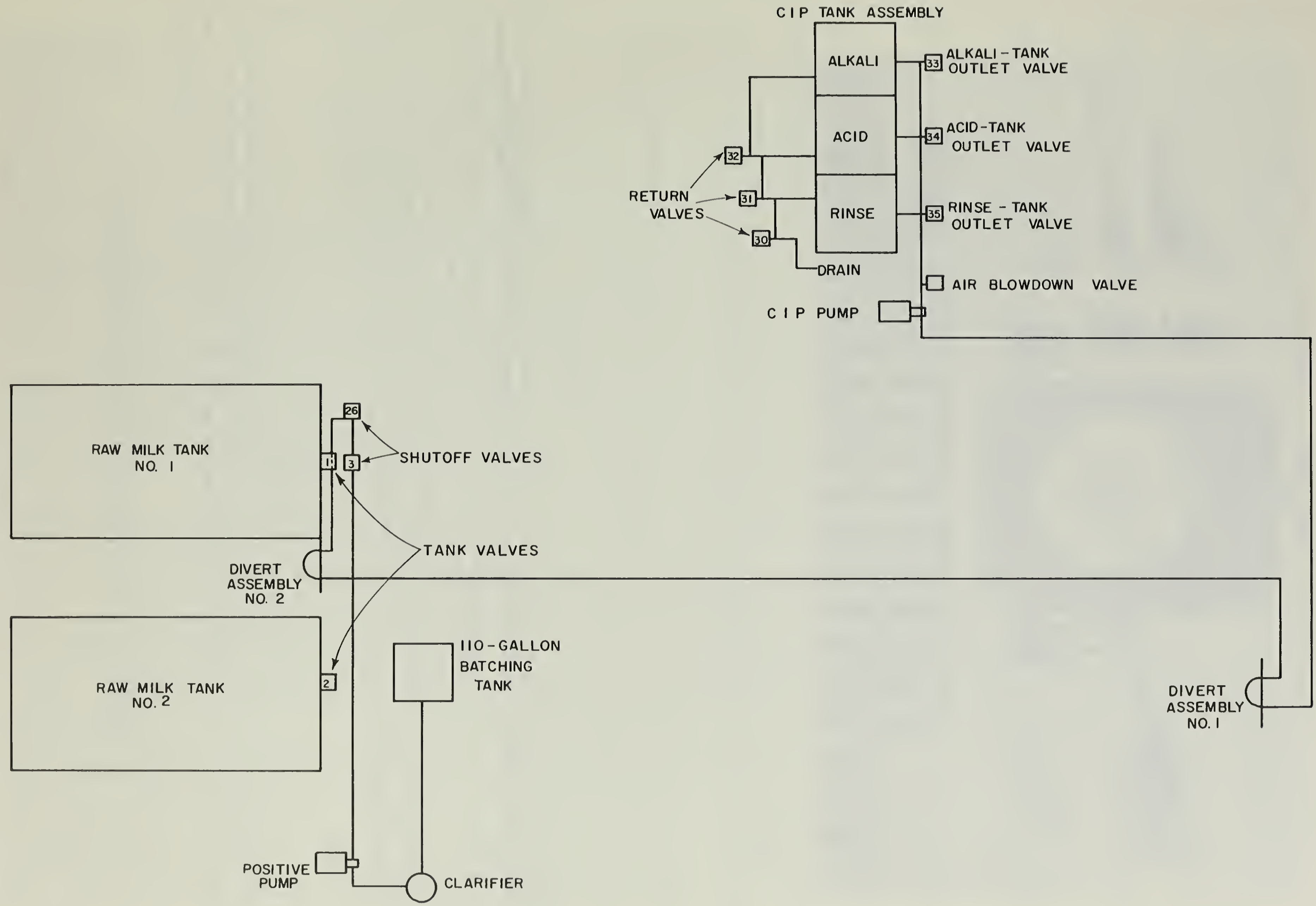

Figure 14.--Schematic diagram of the flow of sanitizing solution from the solution supply tank assembly to the batching tank.

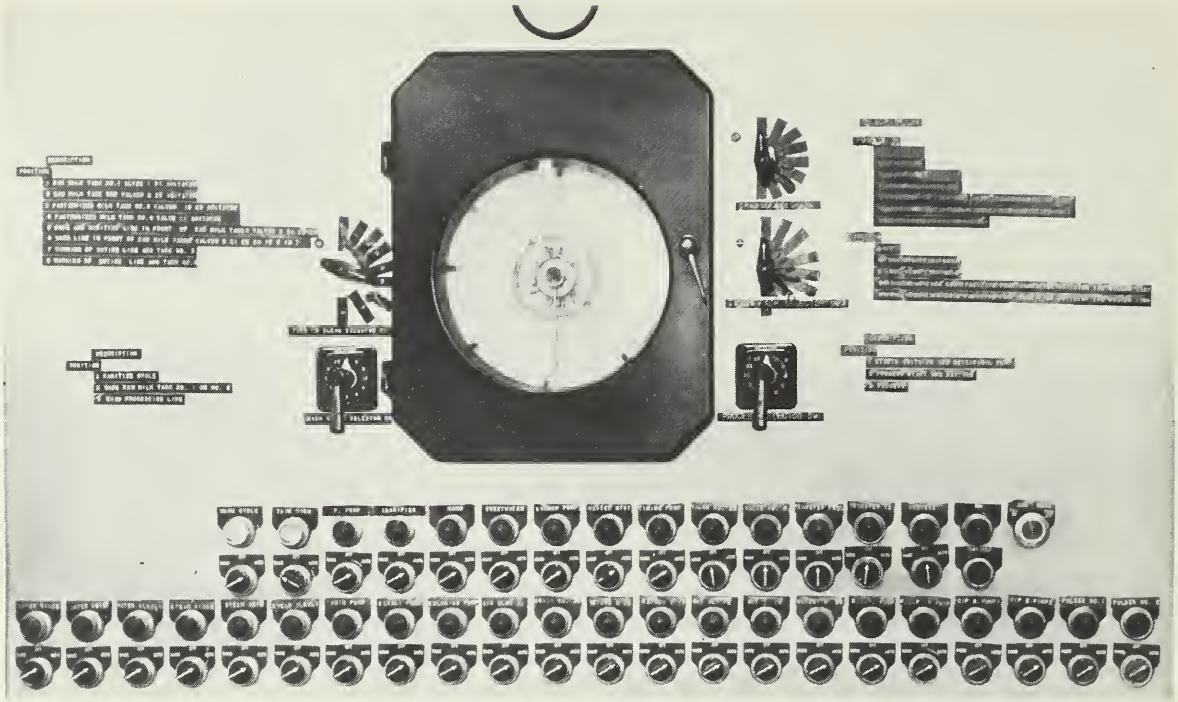

Figure 15.--Control panel with position and selector switches in automatic settings for sanitize cycle.

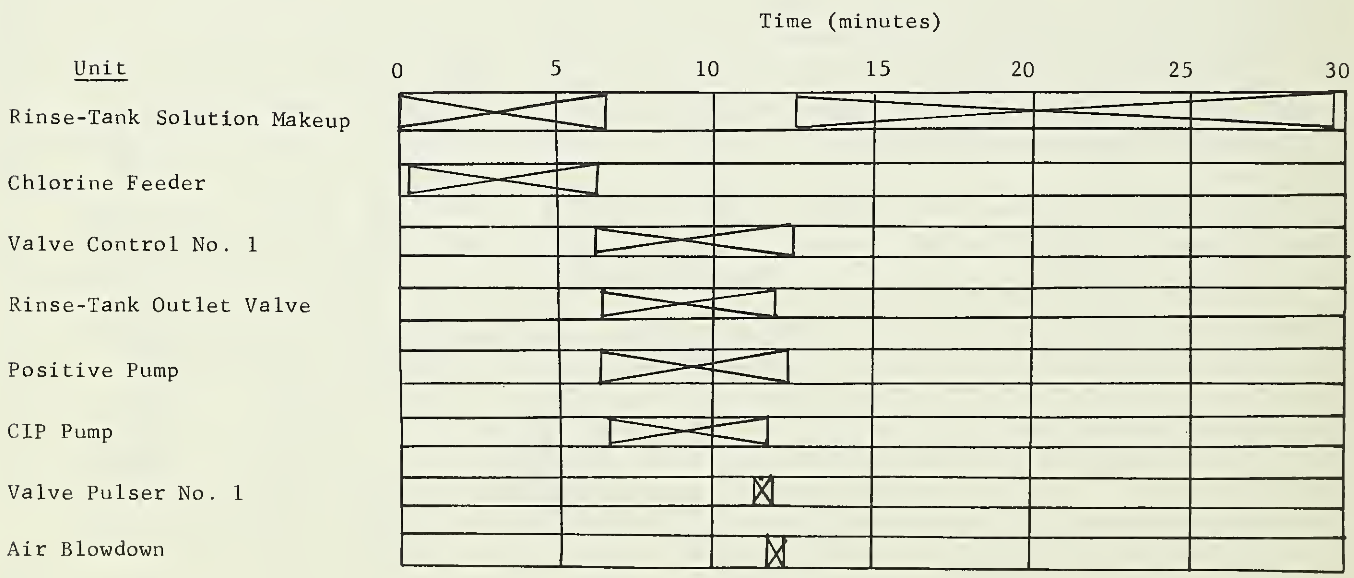

Figure 16.--Sanitize cycle operational chart.

TABLE 1.--Functions of units used in the sanitize cycle

Unit	Description of function
Rinse-tank solution makeup------	Fills rinse tank with water at beginning and end of sanitize cycle.
Chlorine feeder----------------	Meters a predetermined amount of chlorine into rinse tank to prepare sanitizing solution.
Valve control No. 1------------	Positions valves to direct flow of sanitizing solution into raw milk line and to 110-gallon batching tank.
Rinse-tank outlet valve--------	Controls outflow of sanitizing solution from rinse tank during sanitize cycle.
Positive pump------------------	Pumps sanitizing solution into balance tank.
CIP pump-----------------------	Removes sanitizing solution from rinse tank and pumps it through line to balance tank.
Valve pulser No. 1-------------	Pulses valves in front of raw milk tanks during sanitize cycle.
Air blowdown-------------------	Removes solution from CIP line by using air pressure.

While these processes are taking place, another automatic function is accomplished. After the CIP pump stops, the rinse-tank water makeup unit is energized and the rinse tank fills with fresh water. This water will be used as the first rinse water in the next cleaning cycle.

The line valves are closed and the positive pump is stopped. At the end of the 30-minute cycle, the rinse-tank water makeup unit is de-energized and the microswitch controlling the sanitize cycle opens, stopping the motors on the cam timers.

Tank Cleaning Cycle

During the processing day a milk storage tank can be cleaned without interference to the processing operation.

Figure 17 is a flow diagram showing the sequences for cleaning raw milk tank No. 1.

Preparing a milk storage tank for cleaning requires several manual operations. Alkaline detergent is added to the alkali feeding unit reservoir; divert assemblies Nos. 1 and 2 are moved to positions that will direct the flow of cleaning solutions to the milk tank being cleaned. The following position switches for the various units are turned to the "automatic" setting: Rinse-tank solution makeup unit, rinse-tank temperature control unit, alkali-tank solution makeup unit, alkali-tank temperature control unit, alkali feeder unit,

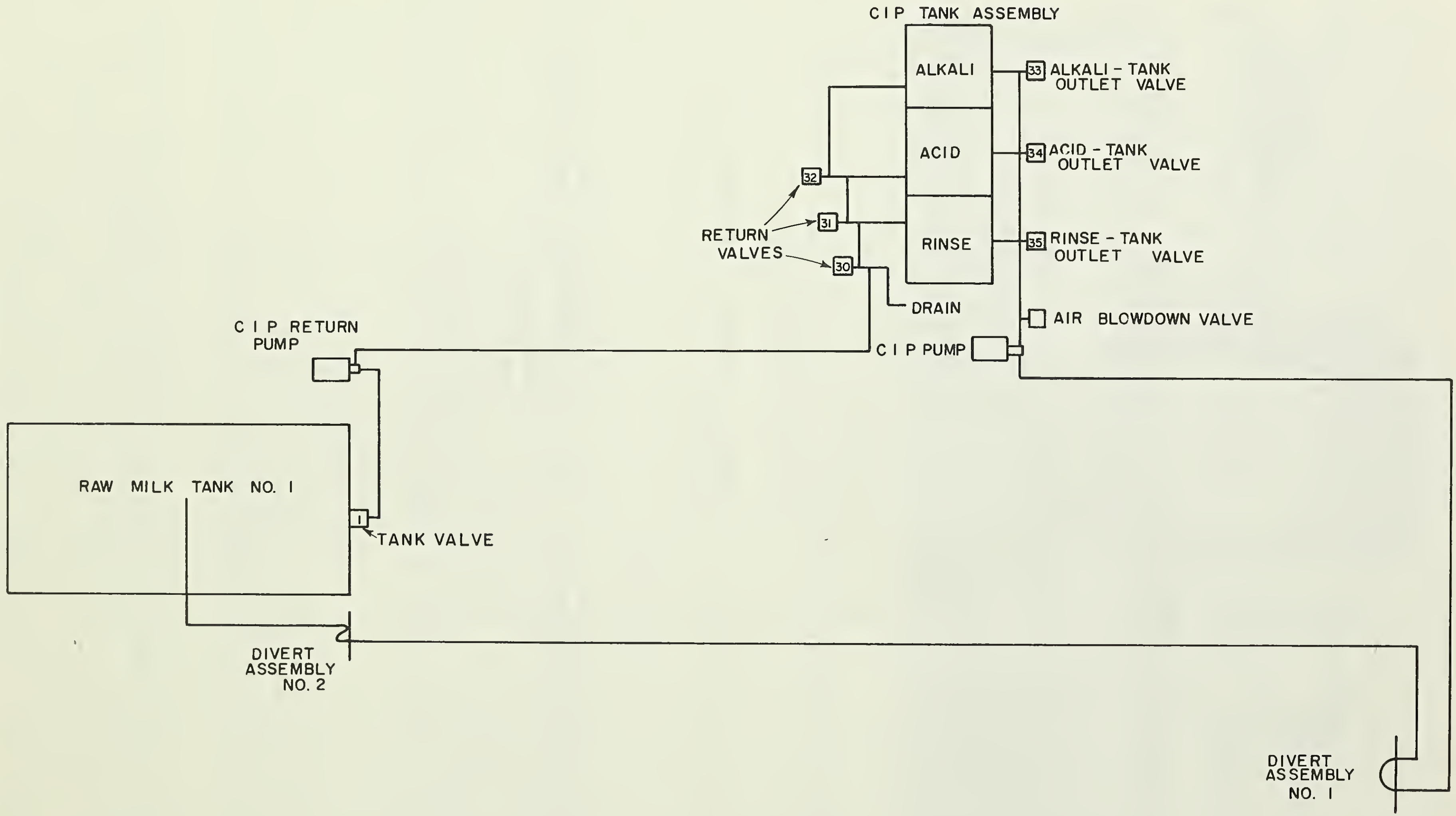

Figure 17.--Schematic diagram of the flow of cleaning solution through raw milk tank No. 1.

rinse-tank outlet valve unit, CIP pump unit, return-to-drain valve unit, CIP return pump unit, alkali-tank outlet valve unit, valve pulser No. 1 unit, air blowdown unit, and return-to-rinse-tank valve unit.

The equipment-to-be-cleaned selector switch is turned to indicate the milk tank to be cleaned. The cleaning-cycle selector switch is placed in the setting for the tank cleaning cycle. The position switches for the equipment-to-be-cleaned selector switch and the cleaning-cycle selector switch are turned to the "automatic" setting, as shown in figure 18.

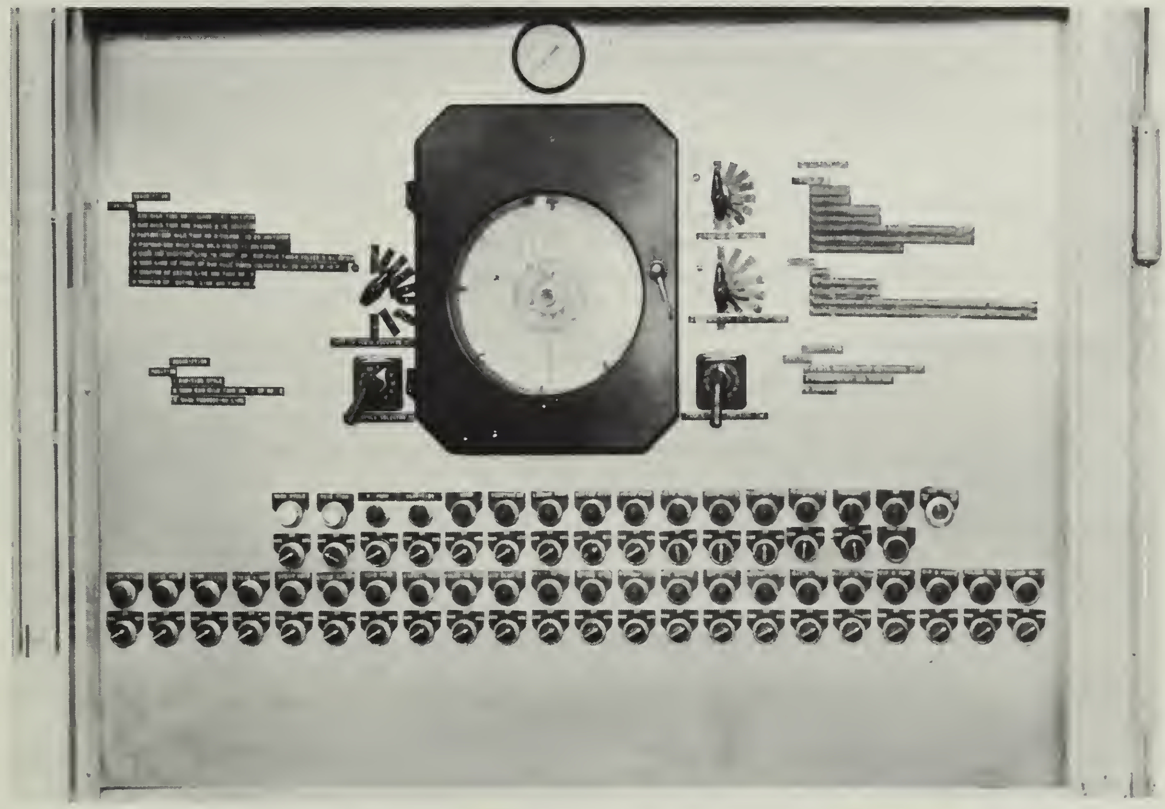

Figure 18.--Control panel with position and selector switches in automatic settings for cleaning a raw milk storage tank.

The tank-cleaning cycle operational chart, figure 19, gives the operating sequences of the different units. Table 2 describes the function of each unit in the cycle.

The tank cleaning cycle has three phases--prerinse, alkaline cleaning, and postrinse. To activate the cleaning operation, the operator depresses the cleaning-cycle start button until the green indicator light stays on when the button is released. The constant light indicates that the system is controlled by a microswitch on the cam timer. As the cam timers rotate, various units are energized by microswitches opened and closed by individual cams.

At the start of the cycle, the rinse tank is automatically filled with rinse water, and the water is heated to a predetermined temperature controlled by the rinse-tank temperature control unit. While the rinse water is being prepared, the alkali-tank solution makeup unit and the alkali-tank temperature control unit are energized first, then the alkali feeder unit is energized to prepare the alkaline cleaning solution.

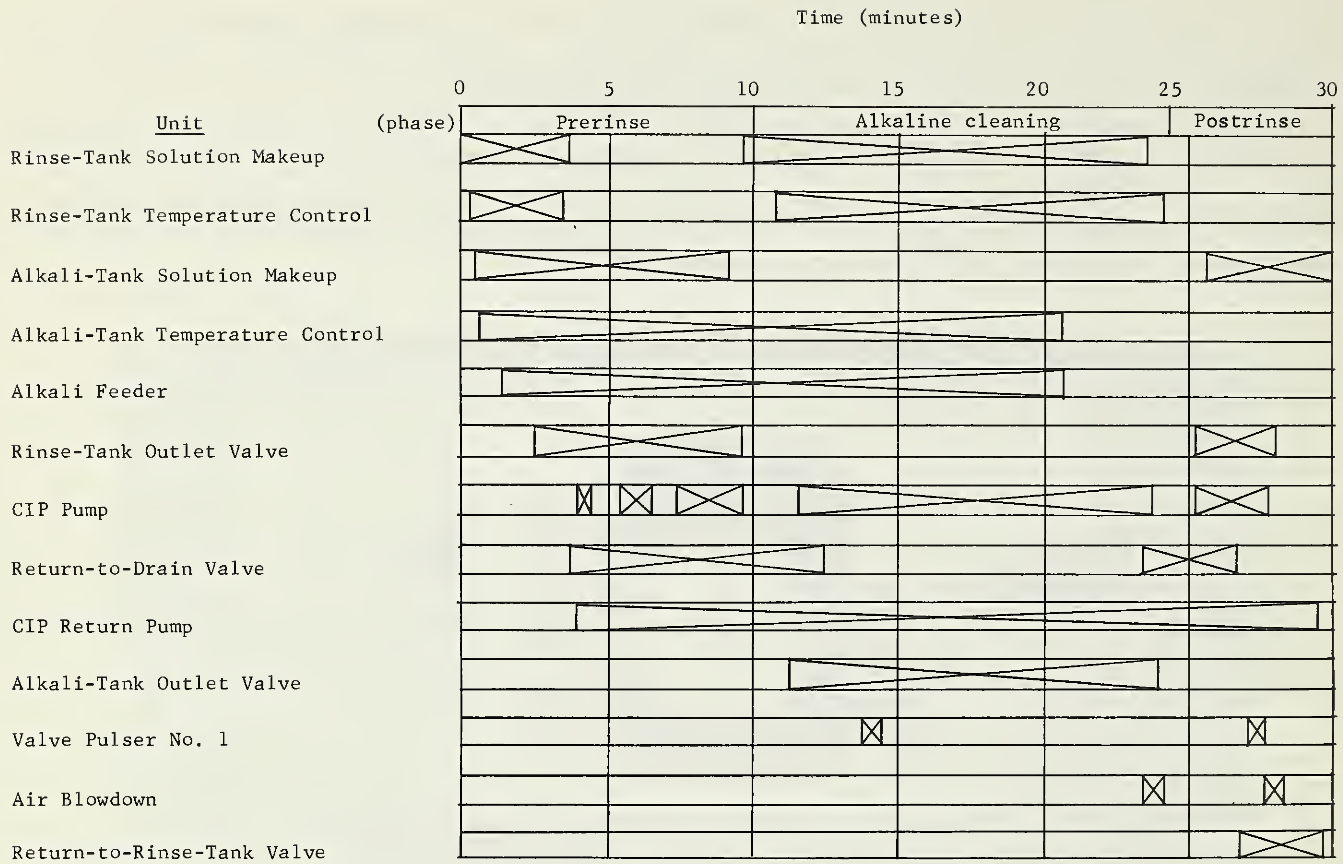

Figure 19.--Tank-cleaning cycle operational chart.

Just before the start of the rinse phase, the rinse-tank water makeup unit and the rinse-tank temperature control unit are de-energized.

To start the rinse phase of the tank cleaning cycle, the automatic control unit opens the outlet rinse valve and the CIP pump starts. The pump circulates the rinse water to the milk storage tank and sprays the tank for 15 seconds. The purpose of this spray rinse is to remove loosely held milk residue from the walls of the storage tank. During this process, the CIP return pump starts and pumps the rinse water back to the CIP tank assembly and down the drain through the return-to-drain valve. The CIP pump is stopped and started three times during the prerinse phase.

The prerinse phase is completed when the rinse-tank outlet valve is closed and the CIP pump is stopped. The CIP return pump continues to remove the prerinse water from the milk tank. The alkali-tank solution makeup unit is de-energized.

The alkaline cleaning phase of the cycle starts when the alkali-tank outlet valve opens and the CIP pump starts. The alkaline cleaning solution follows the same circuit as the rinse water. The CIP return pump moves the solution back to the alkali solution tank where the detergent concentration and solution temperature are maintained. The solution is circulated continuously through this circuit for approximately 14 minutes. The valves in the system being cleaned are pulsed automatically during both the alkaline cleaning and the succeeding postrinse phase of the tank cleaning cycle.

TABLE 2.--Functions of units used in the tank cleaning cycle

Unit	Description of function
Rinse-tank solution makeup------	Fills rinse tank with water.
Rinse-tank temperature control--	Heats rinse water to predetermined temperature.
Alkali-tank solution makeup-----	Fills alkali tank with water.
Alkali-tank temperature control-	Heats alkali-tank water to predetermined temperature.
Alkali feeder-------------------	Automatically meters predetermined amount of alkali cleaning solution into alkali tank.
Rinse-tank outlet valve---------	Removes rinse water from rinse tank.
CIP pump------------------------	Forces rinse water or alkaline solution to equipment being cleaned.
Return-to-drain valve-----------	Diverts rinse water and alkaline solution to drain when solution is being returned to CIP tank.
CIP return pump-----------------	Returns rinse water or alkaline solution from equipment cleaned.
Alkali-tank outlet valve--------	Removes alkaline solution from alkali tank.
Valve pulser No. 1--------------	Pulses valves during cleaning cycle.
Air blowdown--------------------	Removes rinse water or alkaline solution from lines to reduce mixing of rinse water and solution.
Return-to-rinse-tank valve------	Returns rinse water to rinse tank.

During the last part of the alkaline cleaning phase, the return-to-drain valve opens, diverting the solution to the drain. After the time required for the solution tank to be emptied, the outlet valve closes and the CIP pump stops. The air blowdown valve then opens and compressed air is admitted to blow the alkaline solution out of the line to the tank. This procedure prevents mixture of the alkaline cleaning solution with the postrinse water. The CIP return pump continues to operate, removing the alkaline cleaning solution from the milk tank.

During the alkaline cleaning phase of the cycle, the rinse tank is filled with water for the postrinse and the water is heated to a preset temperature.

The postrinse phase is started when the alkaline cleaning phase is completed. The rinse-tank outlet valve is opened and the CIP pump starts. Rinse water is sprayed into the tank. The first part of the rinse water is returned

to the solution tank assembly and diverted to the drain. Enough rinse water must be dumped at the beginning of the postrinse phase to remove most of the residual alkaline detergent. The drain valve then closes, allowing the remaining rinse water to be returned to the rinse tank. At the end of the postrinse phase, the rinse-tank outlet valve closes and the CIP pump stops. Finally, the air blowdown valve opens, blowing the remaining rinse water out of the line. The CIP return pump moves this rinse water back to the rinse tank, where it will be used in prerinse or for sanitizing solution.

At the completion of the 30-minute tank cleaning cycle, the system shuts off automatically.

Processing-Line Cleaning Cycle

At the end of each processing cycle, the processing line must be cleaned. The manual connections required to prepare the processing line and a pasteurized milk storage tank (for descriptive purposes, tank No. 4 is used) for CIP cleaning are:

1. The swivel elbow from pasteurized milk tank No. 4 is attached to the cleaning solution return line (fig. 20).
2. The spray tube in tank No. 4 is connected to a fitting on the milk line in front of this tank (fig. 20). This connection directs the cleaning solution, which has already cleaned the line leading to the Pure-Pak machine, to the tank.
3. The impellers are removed from the positive pump located adjacent to the clarifier (fig. 20).
4. Divert assembly No. 1 is placed in the forward-flow position.
5. Divert assembly No. 2 is placed in the position that allows the cleaning solution to flow into the line in front of the raw milk tanks.
6. A line restriction is removed from the line connecting the flow-diversion valve and constant level tank.
7. The separator-clarifier is removed from the processing line.

The processing-line cleaning cycle is activated when the operator turns all of the position switches for the CIP cleaning units to the automatic setting (fig. 21). The selector switch on the flow-diversion valve control panel is moved to the "clean" setting. The processing selector switches and their respective position switches are turned to the "off" setting.

The equipment-to-be-cleaned selector switch is turned to position 8, which controls the flow of cleaning solution to the entire processing line and also to the line to the Pure-Pak machine and pasteurized milk storage tank No. 4. The equipment-to-be-cleaned position switch is turned to the "automatic" setting; this setting causes the valves to be opened automatically by the programed cam timers. The cleaning-cycle selector switch is moved to the clean processing-line position. The position switch for the cleaning-cycle selector switch is turned to the "on" setting. In this setting, the operator starts the cleaning cycle by pressing the start switch and holding it down until the cleaning-cycle indicator light stays on when this switch is released. A microswitch on one of the programed cam timers assumes control of the cleaning cycle and different cams activate various units during the cycle.

An equipment operational chart for the processing-line cleaning cycle is shown in figure 22. A description of the functions of the components is given in table 3.

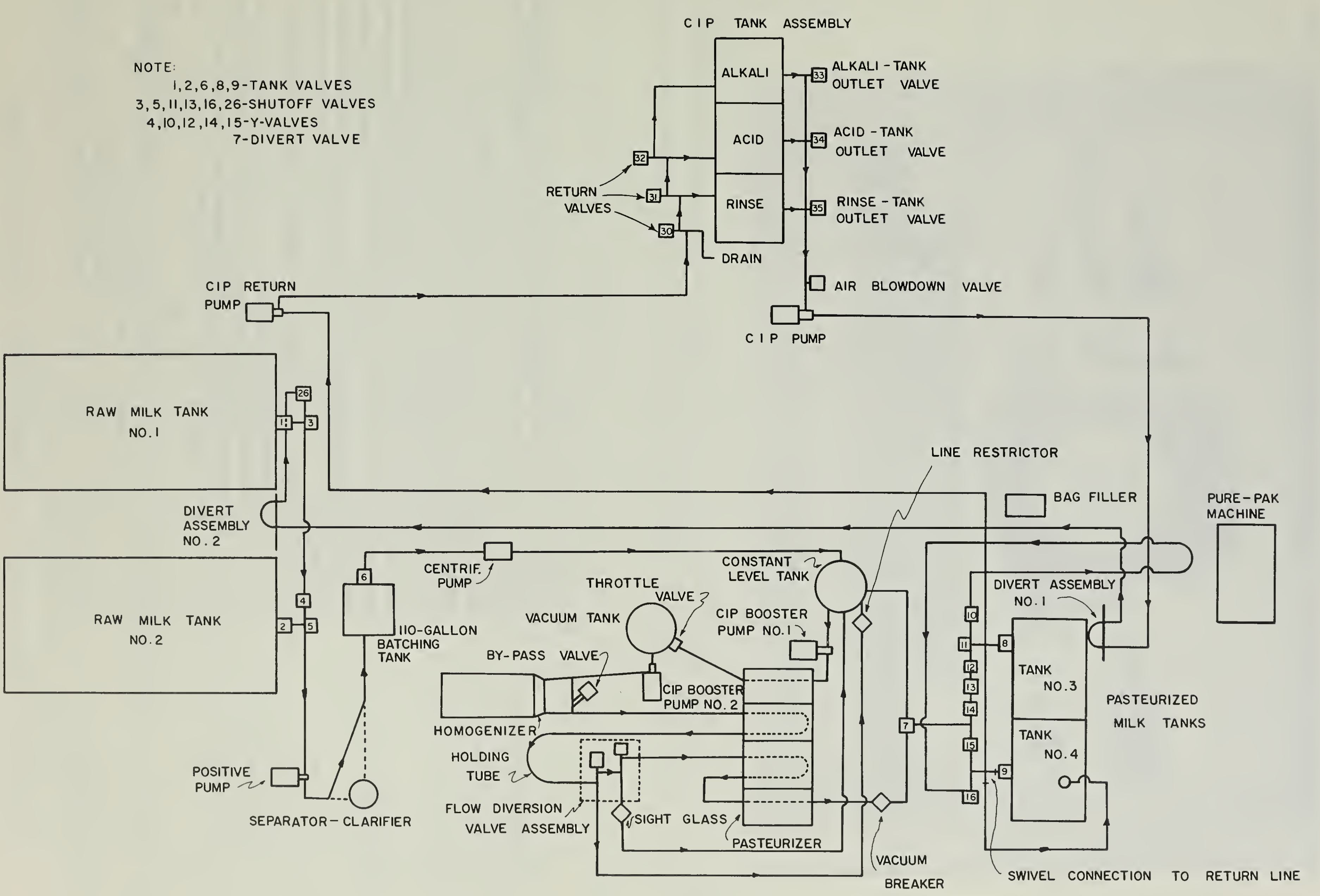

Figure 20.--Schematic diagram of flow of rinse water and cleaning solutions through the processing line.

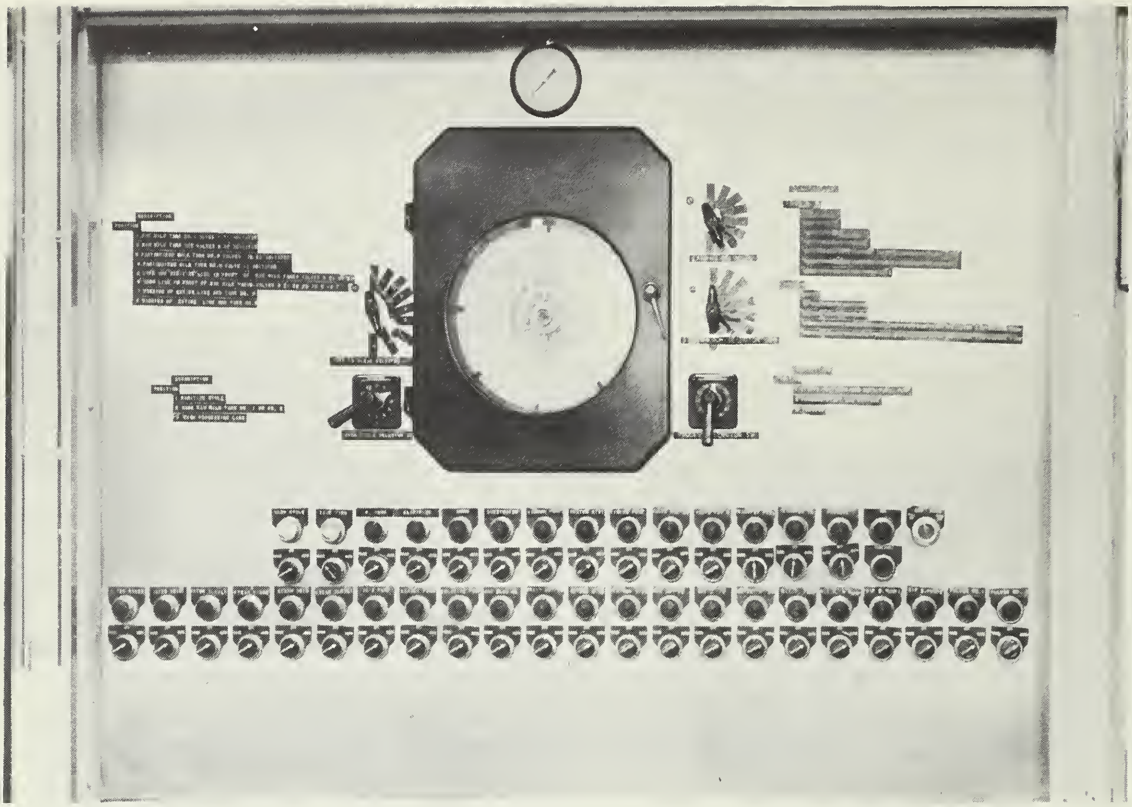

Figure 21.--Control panel with position and selector switches in automatic settings for cleaning the processing line.

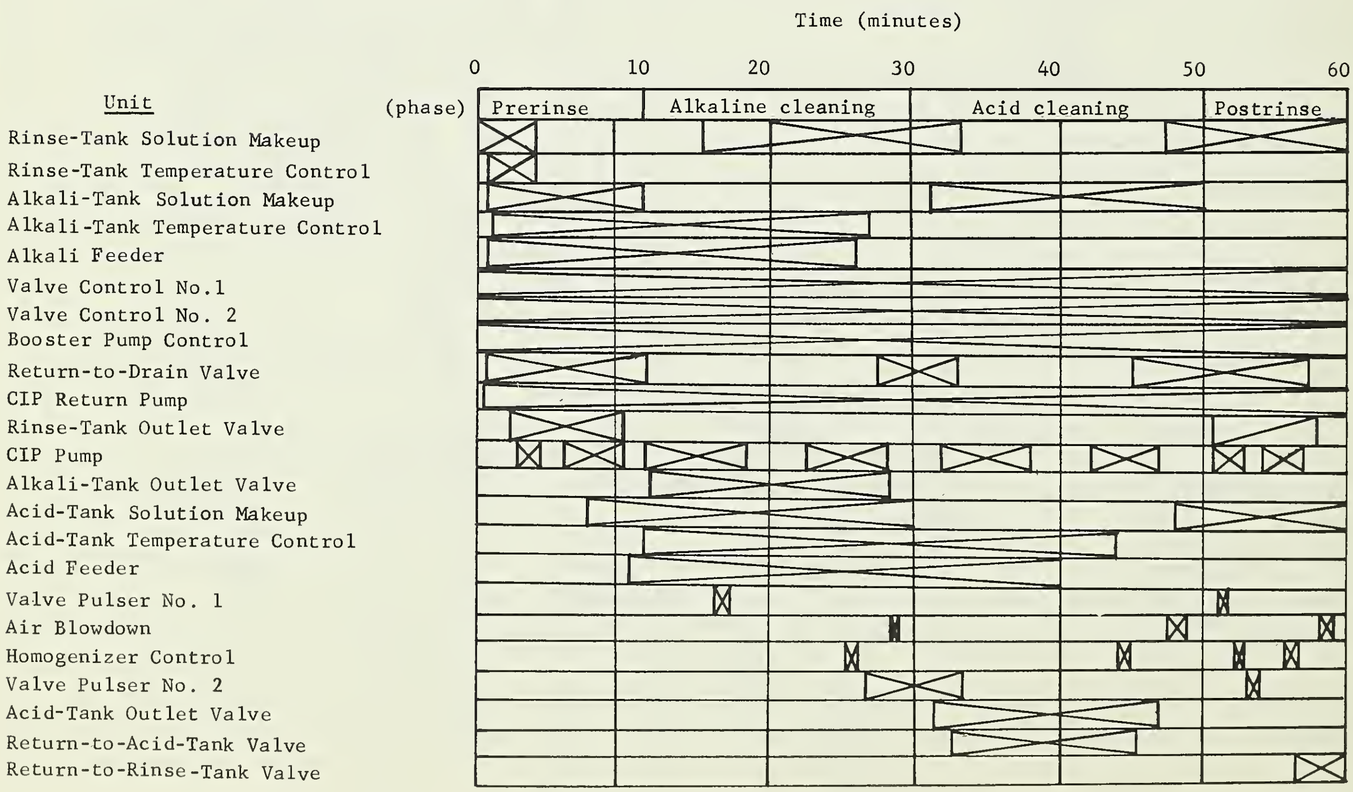

Figure 22.--Processing-line cleaning cycle operational chart.

TABLE 3.--Functions of units used in the processing-line cleaning cycle

Unit	Description of function
Rinse-tank solution makeup------	Fills rinse tank with water during cleaning cycle.
Rinse-tank temperature control--	Heats rinse water to predetermined temperature.
Alkali-tank solution makeup-----	Fills alkali tank with water during cleaning cycle.
Alkali-tank temperature control-	Heats alkaline solution to predetermined temperature.
Alkali feeder-------------------	Adds to and maintains alkaline cleaner strength in alkali tank during alkali cleaning phase of the cycle.
Valve control No. 1-------------	Opens valves in front of raw milk storage tanks during cleaning cycle.
Valve control No. 2-------------	Opens valves in front of pasteurized milk storage tanks during cleaning.
Booster pump control------------	Starts and stops booster pumps Nos. 1 and 2, opens valves Nos. 6 and 7.
Return-to-drain valve-----------	Diverts rinse water and cleaning solution to drain during cleaning cycle.
CIP return pump-----------------	Returns rinse water and cleaning solution to CIP tank.
Rinse-tank outlet valve---------	Allows rinse water to be removed from rinse tank.
CIP pump------------------------	Circulates rinse water and cleaning solutions through CIP line.
Alkali-tank outlet valve--------	Allows alkaline solution to be removed from alkali tank.
Acid-tank solution makeup-------	Fills acid tank with water during cleaning cycle.
Acid-tank temperature control---	Heats acid cleaning solution to predetermined temperature.
Acid feeder---------------------	Meters a predetermined amount of acid cleaning solution into acid tank; maintains its strength.

TABLE 3.--Functions of units used in the processing-line cleaning cycle--Continued

Unit	Description of function
Valve pulser No. 1	Pulses valves in front of raw milk storage tanks.
Air blowdown	Removes rinse water and cleaning solutions from lines to reduce mixing of solutions or rinse water and solutions.
Homogenizer control	Operates homogenizer during cleaning cycle.
Valve pulser No. 2	Pulses valves in front of pasteurized milk tanks.
Acid-tank outlet valve	Allows acid solution to be removed from acid tank.
Return-to-acid tank valve	Diverts returning acid solution into acid tank.
Return-to-rinse-tank valve	Diverts returning rinse water into rinse tank.

The processing-line cleaning cycle includes four phases--prerinse, alkaline cleaning, acid cleaning, and postrinse. Time is required between each phase to allow the solution from the previous phase to be removed from the processing line. The processing-line cleaning cycle requires 60 minutes.

At the start of the prerinse phase, the rinse-tank water makeup valve and the steam valve open, allowing the tank to be filled with water and the water to be heated. Also, the valves are positioned to direct the flow of cleaning solution through the processing line, and the booster pump control and CIP return pump units are energized. Next, the rinse-tank outlet valve is opened and the CIP pump starts circulating the water to rinse the lines and equipment. The rinse water is returned to the CIP tank assembly by the CIP return pump and diverted to the drain by the return-to-drain valve. During the prerinse phase, the CIP pump is stopped and started twice to rinse the processing line. This procedure insures that a maximum amount of product is flushed from the processing line.

Approximately 11 minutes after the start of the cycle, the rinse-tank outlet valve is closed and the CIP pump is stopped. The valve is closed before the pump is stopped to prevent backflow of rinse water from the CIP line into the rinse tank.

During the prerinse phase of the cleaning cycle, the alkali tank is filled with water and the water is heated to the cleaning temperature. The alkali feeder automatically adds alkaline detergent to the water until conductivity of the solution reaches a predetermined level.

After the rinse water has been drained from the processing line and equipment, the alkali-tank outlet valve opens. The CIP pump starts, and circulates

the alkaline solution through the lines and equipment. The CIP pump is started and stopped twice during this phase. The valves in front of the raw and pasteurized milk tanks are pulsed, and the homogenizer is run for several minutes.

The CIP return pump operates during the entire cleaning cycle, returning the cleaning solution to the CIP tank assembly where valves direct it to the proper tank or to the drain. The detergent concentration and the temperature of the returning solution are adjusted automatically, as previously described. The solution is then recirculated through the lines and equipment. This cleaning phase is continued for approximately 16 minutes.

Several minutes before the end of the alkaline cleaning phase, the return-to-drain valve opens, diverting the alkaline solution to the drain. The CIP pump continues to run until the alkali tank is empty; the tank outlet valve then closes and the CIP pump stops. Finally, the air blowdown valve opens, moving the alkaline solution from the CIP line to the batching tank.

During the alkaline cleaning phase, the acid cleaning solution is prepared in the third tank in a manner similar to the preparation of the alkaline solution. When the lines and processing equipment have been drained of the alkaline cleaning solution, the acid-tank outlet valve opens and the CIP pump starts and circulates the acid cleaning solution through the lines and equipment. Before the return-to-drain valve closes, the return-to-acid-tank valve is opened. The detergent concentration and temperature of the acid cleaning solution are maintained in a manner similar to that described for the alkaline solution. The valves are pulsed and the homogenizer is run for several minutes during the acid cleaning phase.

Several minutes before the end of the acid cleaning phase, the return-to-drain valve is opened, diverting the acid solution to the drain. The CIP pump continues to operate, emptying the acid tank. Then the acid-tank outlet valve closes and the CIP pump stops. The air blowdown valve opens, and compressed air blows the acid solution from the outlet line into the batching tank.

During the acid cleaning phase, the rinse tank is again filled with water. The rinse water is not heated because the postrinse water is also used for cooling the lines and equipment.

The postrinse phase begins when the rinse-tank outlet valve is opened and the CIP pump is started. At the same time, the rinse-tank outlet valve opens and remains open during the postrinse phase to insure an adequate supply of cold water for rinsing and cooling the lines and equipment. The CIP pump is run for approximately 2 minutes and stopped. The rinse water circulated during this period flows through the system, removing the remaining part of the acid cleaning solution. The CIP pump then restarts and pumps more rinse water through the system to provide a final rinse.

During the final part of the postrinse, the alkali and acid tanks are again filled with water in preparation for the next cleaning cycle.

Several minutes before the end of the postrinse phase, the rinse-tank outlet valve is closed and the CIP pump is stopped. The air blowdown unit again removes the rinse water from the line and causes it to be returned to the CIP tank assembly, which diverts it to the drain. The homogenizer is run for several minutes and the valves are pulsed several times during the postrinse phase.

At the end of the postrinse phase, the cam timers de-energize all of the pieces of equipment before the microswitch that controls the cam timers opens and stops them.

DESCRIPTION OF SELECTOR SWITCHES

The detailed wiring diagrams of the automated CIP cleaning system installed in the University of Missouri dairy plant are shown in figures 23 through 29. The wiring diagrams and their descriptions are presented to show how the functions previously described were accomplished.

Equipment-to-be-Cleaned Selector Switch

The circuit to the equipment-to-be-cleaned selector switch is controlled by a position switch. This design feature allows the equipment-to-be-cleaned selector switch to be placed in any cleaning setting and its circuit to be energized at a later time.

An indicator light is connected in series with the position switch and in parallel with the selector switch. Thus the indicator light is energized when the position switch is moved to the "on" position. The selector switch circuit is energized either manually, by turning the position switch to the "on" setting, or automatically, by a microswitch on a cam timer that assumes control when the position switch is in the "automatic" setting.

Each selector switch setting will be described as though the system were operated manually.

The different positions on the equipment-to-be-cleaned selector switch are given below:

Switch Position	Description
1	Clean raw milk tank No. 1.
2	Clean raw milk tank No. 2.
3	Clean pasteurized milk tank No. 3.
4	Clean pasteurized milk tank No. 4.
5	Clean line in front of raw milk tanks.
6	Clean line in front of raw milk tanks, line in front of pasteurized milk tanks, and line to Pure-Pak machine.
7	Clean line in front of raw milk tanks, line in front of pasteurized milk tanks, line to Pure-Pak machine, and pasteurized milk tank No. 3.
8	Same as position 7 except also clean pasteurized milk tank No. 4.

Setting No. 1.--Clean raw milk tank No. 1 (diagram 1, fig. 23).

Selection of this setting properly positions the valves and starts the agitator, permitting raw milk tank No. 1 to be CIP cleaned.

The equipment-to-be-cleaned selector switch is moved to the No. 1 setting and its position switch is turned to the "on" setting. The indicator light comes on, indicating that control relay No. 10 (CR-10) has been energized.

When CR-10 is energized, three contact points, CP-1, CP-2, and CP-3 are closed. When these contact points are closed, the following circuits are energized: CP-1, which allows current to flow through the terminal strips to energize the outlet valve unit No. 1 for raw milk tank No. 1; CP-2, which allows current to energize line valve unit No. 3; and CP-3, which energizes the agitator circuit in raw milk tank No. 1. When the valves are in their proper positions and the agitator is started, the tank is ready for CIP cleaning.

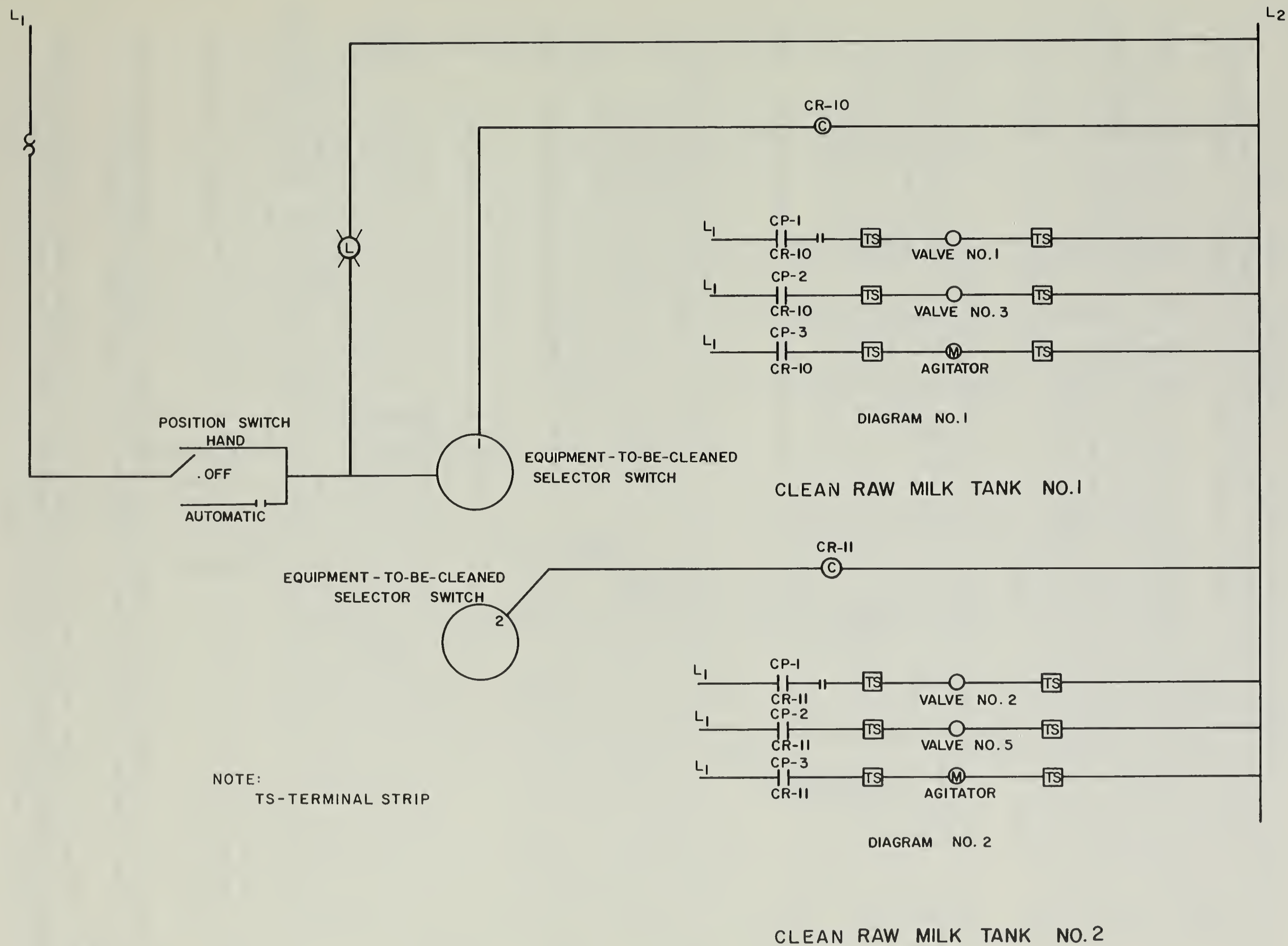

Figure 23.--Equipment-to-be-cleaned selector switch positions 1 and 2.

At the end of the cleaning cycle, the position switch is turned to the "off" setting and CR-10 is de-energized.

Setting No. 2.--Clean raw milk tank No. 2 (diagram 2, fig. 23).

With the equipment-to-be-cleaned selector switch in the No. 2 setting and its position switch in the "on" setting, the indicator light and control relay No. 11 (CR-11) are energized.

The energizing of CR-11 closes CP-1, CP-2, and CP-3. As a result of these closures, CP-1 energizes the milk outlet valve unit No. 2 for raw milk tank No. 2, CP-2 energizes the line valve unit No. 5 in front of raw milk tank No. 2, and CP-3 energizes the agitator unit on raw milk tank No. 2. When all the units are energized, the tank is ready to be CIP cleaned.

At the completion of the cleaning cycle, the position switch is turned to the "off" setting and CR-11 is opened.

Setting No. 3.--Clean pasteurized milk tank No. 3 (diagram 1, fig. 24).

Control relay No. 12 (CR-12) and the indicator light are energized when the position switch is turned to the "on" setting while the equipment-to-be-cleaned selector switch is in setting No. 3. The closing of CP-1, CP-2, and CP-3 in CR-12 causes the following units to be energized: Outlet valve unit No. 8 for pasteurized milk tank No. 3, line valve unit No. 11, and the agitator unit of pasteurized milk tank No. 3.

The circuit is de-energized when the position switch is moved to the "off" setting.

Setting No. 4.--Clean pasteurized milk tank No. 4 (diagram 2, fig. 24).

When pasteurized milk tank No. 4 is to be CIP cleaned, the equipment-to-be-cleaned selector switch is placed in setting No. 4. Then the position switch is turned to the "on" setting; as a result, the indicator light is energized for the selector switch, outlet valve unit No. 9 is opened, and the agitator unit for pasteurized milk tank No. 4 is started.

The circuit controlled by setting No. 4 is de-energized when the position switch is turned to the "off" position.

Setting No. 5.--Clean the line in front of raw milk tanks (diagram 1, fig. 25).

With the selector switch in setting No. 5 and the position switch in the "on" setting, CR-13 is energized. The closing of CP-1 on CR-13 energizes valve unit No. 26, the valve unit that allows cleaning solution to enter the raw milk line. Valve unit Nos. 3 and 5 are energized by the closing of CP-2 and CP-3. These valve units prevent flow into the lines leading to raw milk tanks Nos. 1 and 2, respectively. CP-4 closes and energizes valve unit No. 4; this energized valve unit allows the cleaning solutions to flow through the line in front of the raw milk tanks.

The position switch is turned to the "off" setting to de-energize selector switch circuit No. 5.

Setting No. 6.--Clean milk lines in front of the raw and pasteurized milk tanks and line leading to the Pure-Pak machine and bag filler (diagram 2, fig. 25).

The indicator light and control relays CR-13 and CR-14 are energized when the position switch is moved to the "on" setting while the equipment-to-be-cleaned selector switch is in setting No. 6.

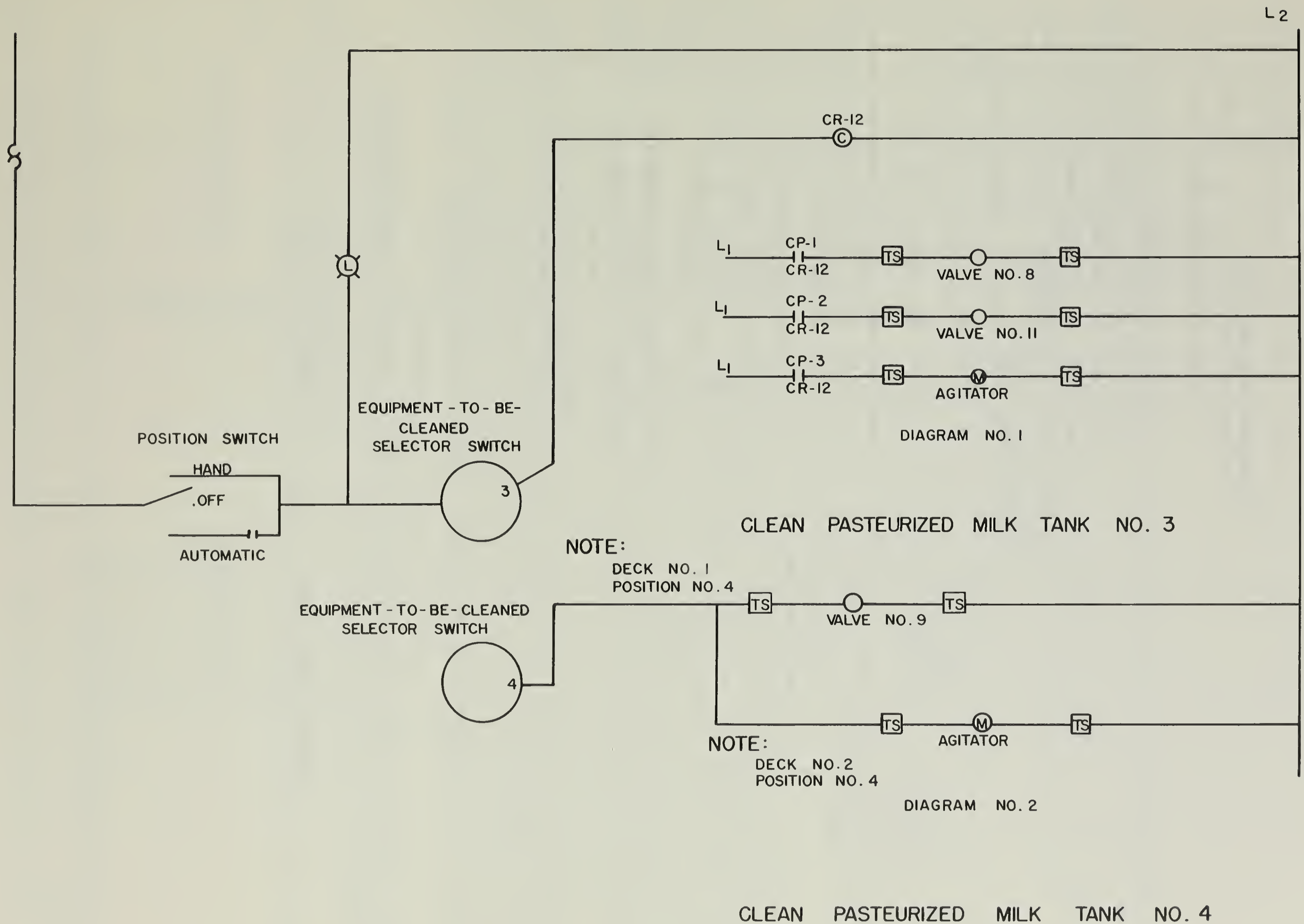

Figure 24.--Equipment-to-be-cleaned selector switch positions 3 and 4.

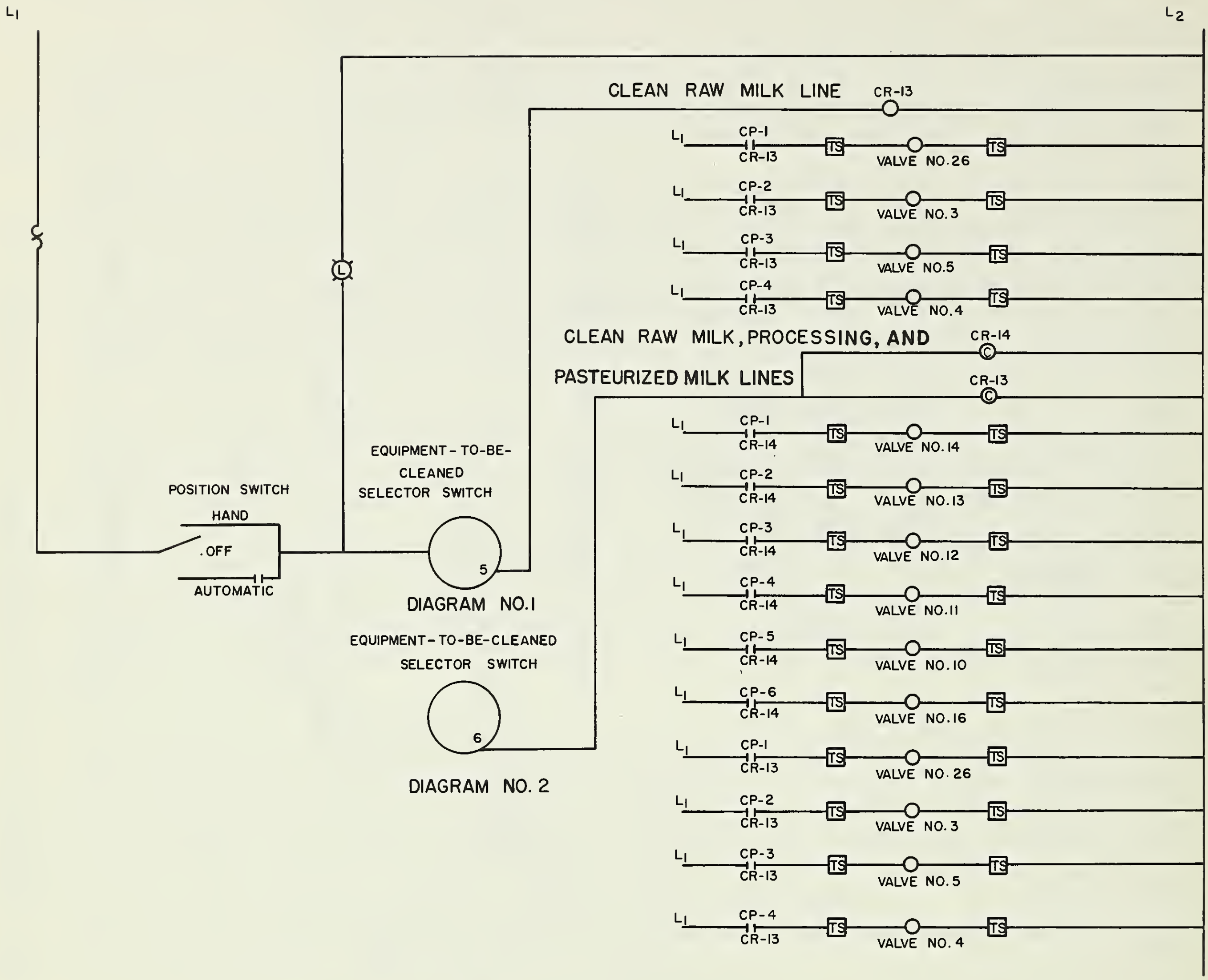

Figure 25.--Equipment-to-be-cleaned selector switch positions 5 and 6.

The closing of CP-1 through CP-6, on CR-14, energizes the following circuits:

Contact Point No.	Valve Unit No.
1	14
2	13
3	12
4	11
5	10
6	16

The following circuits are energized by the closing of CP-1 through CP-4 on CR-13:

Contact Point No.	Valve Unit No.
1	26
2	3
3	5
4	4

Setting No. 7.--Clean milk lines in front of the raw and pasteurized milk tanks, line leading to the Pure-Pak machine and bag filler, and pasteurized milk tank No. 3 (diagram 1, fig. 26).

With equipment-to-be-cleaned selector switch setting No. 7, the indicator light and control relays CR-12, CR-13, and CR-14 are energized when the position switch is turned to the "on" setting.

The closing of CP-1 through CP-4 on CR-13, and CP-1 through CP-6 on CR-14, energizes the circuits, as explained in the description for setting No. 6 of this selector switch. As shown in diagram 1, figure 26, the energizing of CR-12 causes CP-1 to be energized; this circuit closes and energizes valve unit No. 8, the outlet valve unit of pasteurized milk tank No. 3. Valve unit No. 11 is energized by CP-2 to prevent cleaning solution from flowing into the pipe leading to pasteurized milk tank No. 3. CP-3 closes, causing the agitator unit in pasteurized milk tank No. 3 to be energized.

Setting No. 8.--Clean lines in front of the raw and pasteurized milk tanks, line leading to the Pure-Pak machine and bag filler, and pasteurized milk tank No. 4 (diagram 2, fig. 26). (During the processing-line cleaning cycle, cleaning solution is also directed into and out of the processing line by this switch setting.)

The indicator light, CR-13, and CR-14 are energized when the position switch is turned to the "on" setting while the selector switch is in setting No. 8.

A description of the operation of CR-13 and CR-14 is given in the description of selector switch setting No. 6. The agitator circuit for pasteurized milk tank No. 4 is energized directly from deck No. 3 on the selector switch. Valve No. 9, the outlet valve for pasteurized milk tank No. 4, is energized from deck No. 2 on this switch.

Cleaning-Cycle Selector Switch

The cleaning-cycle selector switch is used to choose one of the three cycles (sanitize, tank cleaning, and processing-line cleaning), as shown in figures 27, 28, and 29, respectively.

The different positions on the cleaning-cycle selector switch are given below:

Switch Position	Description
0	Off
1	Sanitize cycle
2	Tank cleaning cycle
3	Processing-line cleaning cycle

To activate any cycle, all of the position switches pertaining to the cycles are placed in the "automatic" setting. The selector switch is first

CLEAN TANK NO. 3, AND RAW MILK, PROCESSING, AND PASTEURIZED MILK LINES

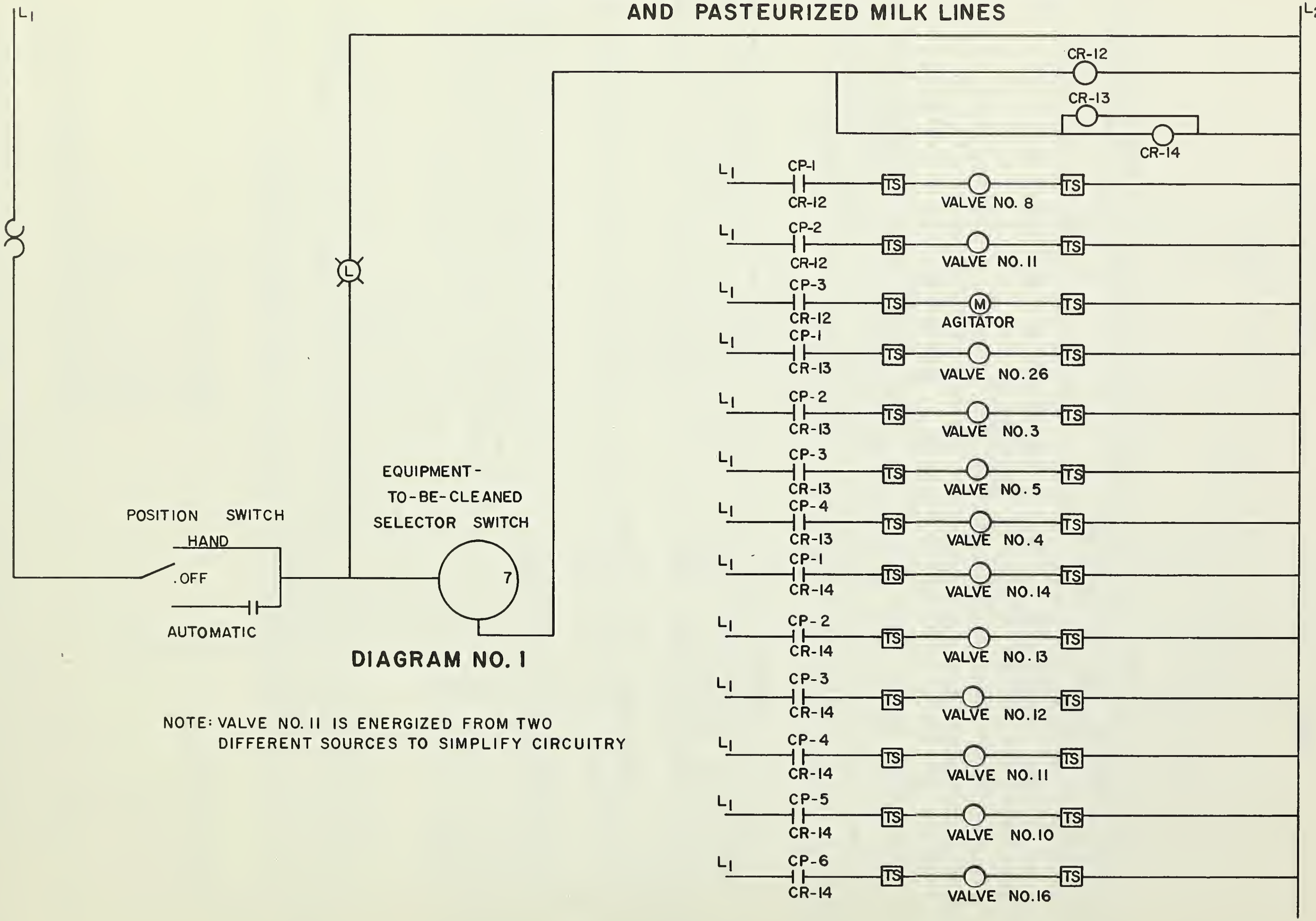

DIAGRAM NO. 1

NOTE: VALVE NO. 11 IS ENERGIZED FROM TWO DIFFERENT SOURCES TO SIMPLIFY CIRCUITRY

CLEAN TANK NO. 4, AND RAW MILK, PROCESSING, AND PASTEURIZED MILK LINES

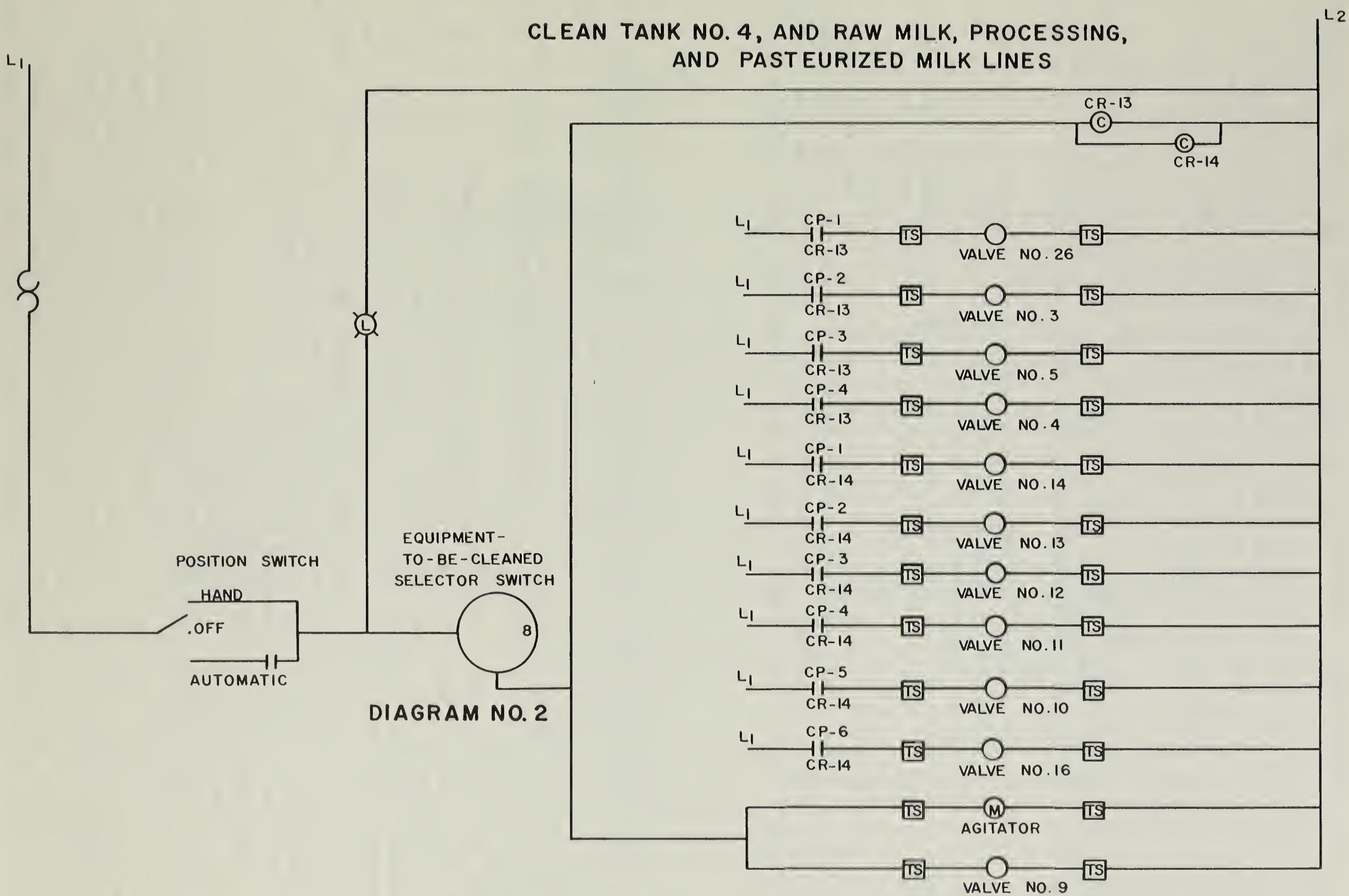

Figure 26.--Equipment-to-be-cleaned selector switch positions 7 and 8.

moved to the correct cycle setting; for example, the selector switch is placed in the No. 2 setting--tank cleaning cycle--and its position switch is moved to the "on" setting. With the position switch in the "on" setting, the appropriate relay for the cycle is energized and a set of contact points is closed. This closure allows current to flow to the motors on the cam timers when the start button is pressed. If the position switch is left in the "off" setting, the relay is not energized and the circuit to the motors on the cam timers cannot be energized.

The start button is depressed and held down approximately 20 seconds. This time interval allows the motors to turn the cams enough to close the microswitch that controls the cam timer motors during the cycle. A microswitch is denoted by CT-No.-No.; for example, microswitch CT-1-2 means microswitch No. 2 on cam timer No. 1.

The cleaning-cycle selector switch is wired (1) to prevent a cycle from accidentally being changed to another cycle, and (2) to prevent the cycle from being shortened without reprograming of the cam timers. The cycle may be lengthened at any time during the operation by turning the position switch to the "off" setting or by rotating the cleaning-cycle selector switch to a different setting. Either action breaks the circuit to the cam timer motors. The cycle is restarted by turning the position switch to the "on" setting or turning the cleaning-cycle selector switch back to the correct setting. When the selector switch is moved to another setting, the cycle for the new setting is not started because the control microswitch on the cam timer for the cycle is not engaged.

Sanitize Cycle

The following information is a detailed description of the sanitize cycle and the components involved. The wiring diagram for the sanitize cycle is given in figure 27. Figure 16 and table 1 show the operational chart and unit functions, respectively.

Before the cycle is started, the equipment-to-be-cleaned selector switch (fig. 25) is placed in setting No. 5, and its position switch is moved to the "automatic" setting.

When the various unit position switches are in the "automatic" setting, the sanitize cycle is activated by the cleaning-cycle selector switch, which is placed in setting No. 1 (sanitize cycle). The position switch for the cleaning-cycle selector switch is moved to the "on" setting. The indicator light for the cleaning-cycle selector switch and relay No. 1 are energized. Next, the cleaning-cycle start button is depressed for several seconds. With the closing of contact points in the start switch, current flows through relay No. 1 to cam timer motors Nos. 1 and 2, which turn the cams. As the cam on timer No. 1 rotates, the cam closes microswitch CT-1-1; this microswitch controls the motors on cam timers Nos. 1 and 2 during the cycle.

As the cams rotate at the beginning of the sanitize cycle, microswitch CT-2-2 closes. By closing, the microswitch energizes the rinse-tank solution makeup unit, which fills the rinse tank with water. Approximately 1 minute after microswitch CT-2-2 closes, microswitch CT-1-3 closes and energizes the chlorine feeder unit. The chlorine unit operates for a predetermined period of time, according to the amount of chlorine which is to be added to the water, then microswitch CT-1-3 opens, thereby de-energizing the unit.

Five minutes after the start of the cycle, microswitch CT-1-7 closes, energizing relay "M." This relay energizes various valve units that direct the

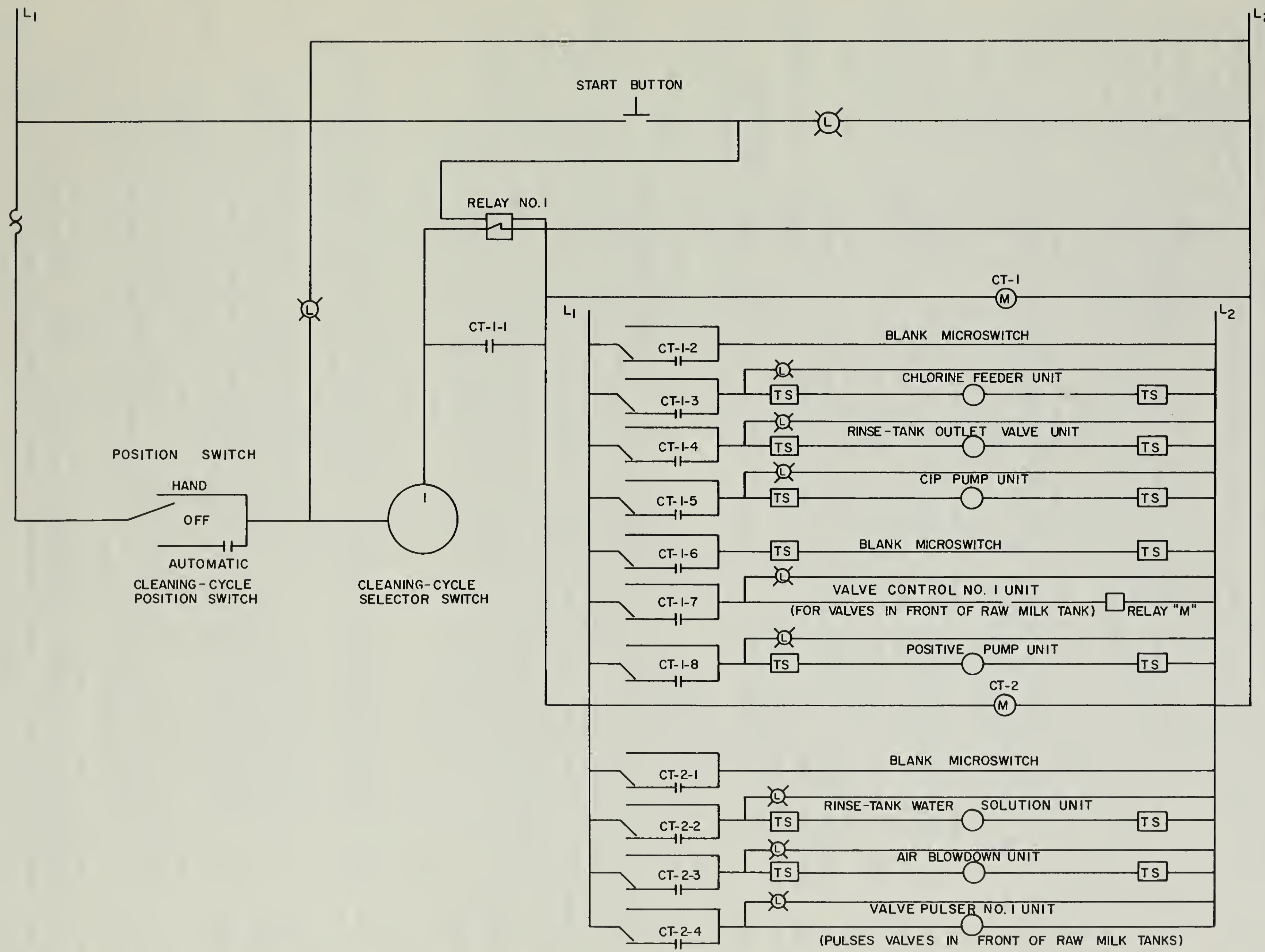

Figure 27.--Wiring diagram for the sanitize cycle.

flow of sanitizing solution through the line in front of the raw milk tanks, through the positive pump and separator-clarifier, and into the 110-gallon tank. Then microswitch CT-1-8 closes, starting the positive pump. During the processing cycle the positive pump is used to pump milk from either of the raw milk tanks into the 110-gallon batching tank.

After the cycle has operated for 5.5 minutes, microswitch CT-2-2 opens, de-energizing the rinse-tank solution makeup unit. Microswitches CT-1-4 and CT-1-5 then close, energizing the rinse-tank outlet valve unit and starting the CIP pump, respectively. The pump circulates the sanitizing solution through the system.

After the sanitizing solution has been removed from the rinse tank, microswitch CT-1-4 opens and de-energizes the rinse-tank outlet valve unit. Then microswitch CT-1-5 opens, stopping the CIP pump. Next, microswitch CT-2-4 closes, starting the pulser No. 1 unit. The pulser unit is energized during this part of the cycle so that the valve outlets can be sanitized without momentarily restricting the flow of sanitizing solution through the clarifier and positive pump. The valves are pulsed twice before microswitch CT-2-4 opens to de-energize the pulsing unit. Finally, microswitch CT-2-3 closes, energizing the air blowdown unit that forces the sanitizing solution from the lines. The air blowdown unit is energized for approximately 25 seconds.

Two minutes after the rinse-tank outlet valve is de-energized, microswitch CT-2-2 closes and energizes the rinse-tank solution makeup unit.

After the air blowdown unit is de-energized, microswitches CT-1-7 and CT-1-8 open; in opening, the microswitches de-energize relay "M" and stop the positive pump, respectively.

The sanitizing solution is now located in the 110-gallon batching tank. The cycle is completed except for the refilling of the rinse tank.

At the end of the cycle microswitch CT-2-2 opens, de-energizing the rinse-tank solution makeup unit. Then microswitch CT-1-1 opens, breaking the circuit to the motors on the cam timers and the cleaning-cycle indicator light. The de-energizing of the indicator light shows that the cycle has been completed. However, the indicator light for the cleaning-cycle selector switch remains on to indicate that the selector's position switch is still in the "on" setting. The position switch is manually turned off to end the automated cycle.

Tank Cleaning Cycle

The tank cleaning cycle is used to clean any of the four milk storage tanks--two raw milk tanks, Nos. 1 and 2, and two pasteurized milk tanks, Nos. 3 and 4.

For illustrative purposes in the following section, raw milk tank No. 1 is presumed to be undergoing cleaning. (Figure 19 and table 2 show the tank-cleaning cycle operational chart and unit functions, respectively.)

To start the tank cleaning cycle, the operator places the equipment-to-be-cleaned selector switch in the No. 1 setting (for clean raw milk tank No. 1) and turns its position switch to the "automatic" setting. Before the cycle is selected, the position switches of the units that will be used during the cycle are turned to the "automatic" setting. The cleaning-cycle selector switch is placed in setting No. 2, tank cleaning cycle (fig. 28). The position switch for the cleaning-cycle selector switch is turned to the "on" setting. The position switch indicator light and relay No. 2 are energized so that the tank cleaning cycle can be started.

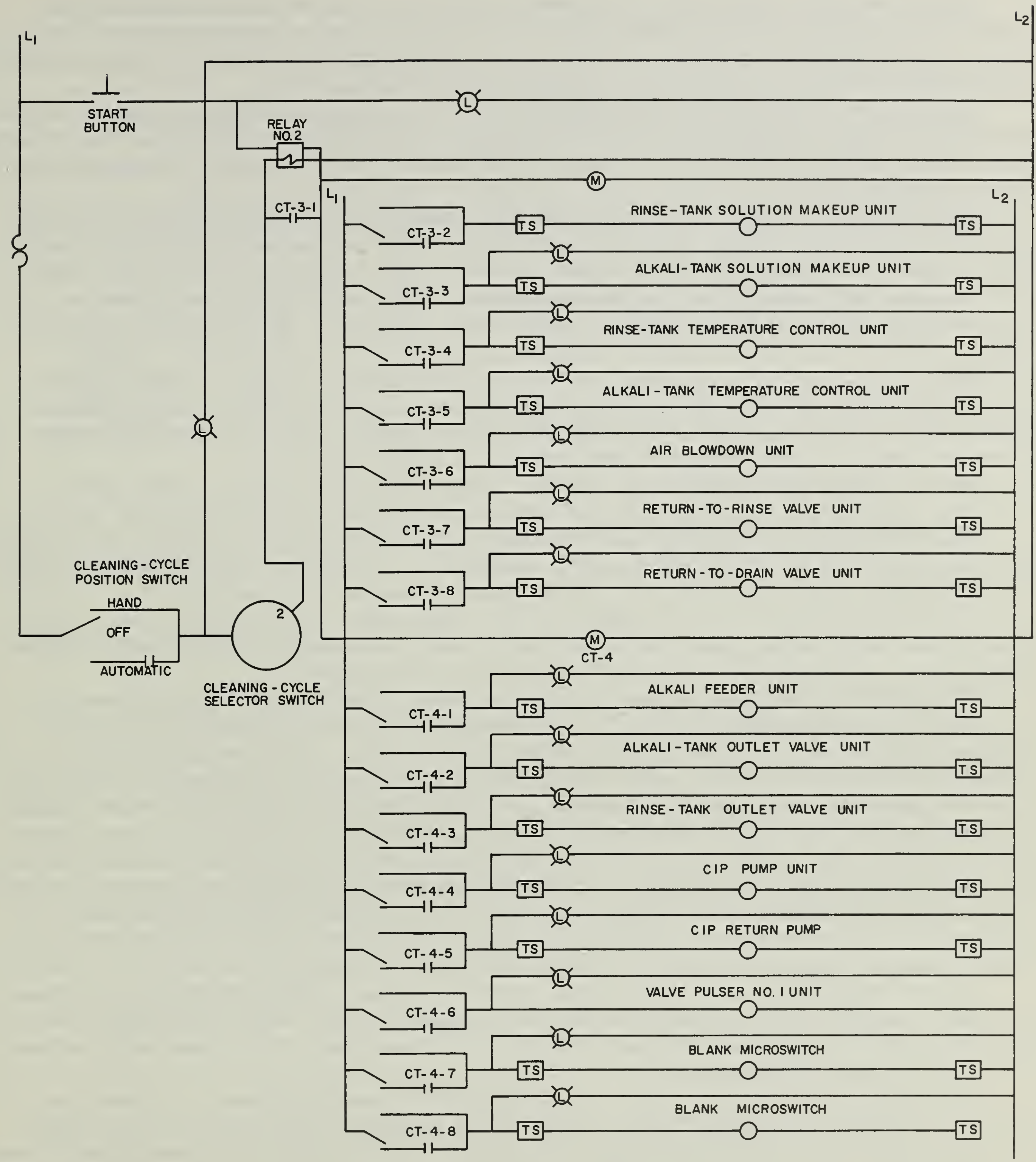

Figure 28.--Wiring diagram for the tank cleaning cycle.

The cleaning-cycle start button is depressed until the start button indicator light stays on when the button is released--an indication that microswitch CT-3-1 has assumed control of the motors on cam timers Nos. 3 and 4 for the duration of the cleaning cycle. The length of the cycle, during which the cams make one revolution, is 30 minutes.

At the start of the cycle microswtich CT-3-2 closes and energizes the rinse-tank solution makeup unit, which fills the rinse tank with water. The closure of microswitch CT-3-4 energizes the rinse-tank temperature control unit, which heats the rinse water to a predetermined temperature.

As the cycle continues, microswitch CT-3-3 closes, energizing the alkali-tank solution makeup unit, and microswitch CT-3-5 closes, activating the alkali-tank temperature control unit. Next, microswitch CT-4-1 closes, energizing the alkali feeder unit.

Three minutes after the cycle has been started, microswitch CT-4-3 closes, energizing the rinse-tank outlet valve unit. Next, microswitches CT-3-2 and CT-3-4 open, de-energizing the rinse-tank solution makeup unit and the rinse-tank temperature control unit, respectively. Microswitch CT-4-4 closes to energize the motor starter, which starts the CIP pump. As a result, water is pumped out of the rinse tank and sprayed into the milk tank being cleaned. Next, microswitch CT-3-8 closes, energizing the return-to-drain valve unit; this valve unit directs the returning rinse water to the drain. Then microswitch CT-4-5 closes and starts the CIP return pump, which returns the rinse water to the CIP tank assembly and directs it down the drain.

The CIP pump is started and stopped three times during the rinse phase, as shown in figure 19, to insure adequate rinsing of the milk tank.

When the rinse tank has been emptied, microswitch CT-4-3 opens, de-energizing the rinse-tank outlet valve unit. Microswitch CT-4-4 opens, de-energizing the CIP pump. However, the CIP return pump continues to operate.

By the completion of the rinse phase, the alkali tank will not only have been filled with water, but the water will have been heated to a predetermined temperature and alkaline detergent will have been added.

The alkaline cleaning phase is started when microswitch CT-3-3 opens, de-energizing the alkali-tank solution makeup unit, and microswitch CT-4-2 closes, energizing the alkali-tank outlet valve unit. Microswitch CT-4-4 closes, restarting the CIP pump. The alkaline solution is pumped through the line and sprayed into the tank; there, it is picked up by the CIP return pump and returned to the CIP tank assembly. The solution is diverted to the drain until microswitch CT-3-8 opens. The opening of this microswitch de-energizes the return-to-drain valve unit so that the cleaning solution is returned to the alkali tank. The alkaline cleaning phase of the cycle lasts approximately 14 minutes and includes pulse cleaning of the air actuated valves on the raw milk tank. Microswitch CT-4-6 closes intermittently to energize valve pulser No. 1.

At the beginning of the alkaline cleaning phase, microswitch CT-3-2 closes and thus energizes the rinse-tank solution makeup unit. When the cycle has been operating for 12 minutes, microswitch CT-3-4 closes and the rinse-tank temperature control unit is energized.

Two minutes before the end of the alkaline cleaning phase, microswitch CT-3-8 is closed and accordingly, the return-to-drain valve unit is energized to direct the flow of the returning solution to the drain. Microswitches CT-4-1 and CT-3-5 open, de-energizing the alkali feeder unit and the alkali temperature control unit. When the alkali tank is empty, microswitch CT-4-2 opens and de-energizes the alkali-tank outlet valve unit. After microswitch CT-4-4 opens, de-energizing the CIP pump circuit, microswitch CT-3-6 closes for approximately 25 seconds, energizing the air blowdown unit.

After the closing of the alkali-tank outlet valve, microswitch CT-3-3 also closes, energizing the alkali-tank solution makeup unit. The CIP return pump continues to operate, returning the cleaning solution to the drain through the return-to-drain valve.

The postrinse phase starts with the closure of microswitch CT-4-3, which energizes the rinse-tank outlet valve unit. Microswitch CT-3-2 opens, de-energizing the rinse-tank solution makeup unit, and microswitch CT-3-4 opens, de-energizing the rinse-tank temperature control unit. Then microswitch CT-4-4 energizes the CIP pump circuit. Microswitch CT-3-7 closes, energizing the return-to-rinse-tank valve unit. Microswitch CT-3-8, which controls the return-to-drain valve unit, remains closed for several minutes at the beginning of the postrinse phase to direct the returning rinse water to the drain.

At the end of the postrinse phase, microswitch CT-4-3 opens, de-energizing the rinse-tank outlet valve unit and microswitch CT-3-3 opens, de-energizing the alkali-tank solution makeup unit. The CIP pump is then stopped by the opening of microswitch CT-4-4, which de-energizes the motor starter. Microswitch CT-3-6 closes for about 25 seconds, energizing the air blowdown unit.

The CIP return pump continues to operate for several minutes, emptying the tank of rinse water. Microswitch CT-4-5 then opens, stopping the CIP return pump, and microswitch CT-3-7 opens, de-energizing the return-to-rinse-tank valve unit.

At the end of the cycle, microswitch CT-3-1 opens and breaks the circuit that allows current to flow to the motors on cam timers Nos. 3 and 4 and also energizes the cleaning-cycle indicator light. The indicator light for the selector switch remains on until the position switch is moved to the "off" position.

Processing-Line Cleaning Cycle

The processing-line cleaning cycle consists of four phases--prerinse, alkaline cleaning, acid cleaning, and postrinse. A unit operation chart of the cleaning cycle is shown in figure 22. The various unit functions are given in table 3. The wiring diagram of the processing-line cleaning cycle is given in figure 29. The pieces of equipment to be cleaned during the processing-line cleaning cycle are selected by choosing one of three settings, No. 6, 7, or 8, on the equipment-to-be-cleaned selector switch. (The different settings were explained in the description of the equipment-to-be-cleaned selector switch.)

In the following explanation of the processing-line cleaning cycle, the processing equipment line, lines in front of the raw and pasteurized milk tanks, line leading to the Pure-Pak machine and bag filler, and pasteurized milk tank No. 4 will be considered as a unit.

The equipment-to-be-cleaned selector switch is moved to setting No. 8 and its position switch to the "automatic" setting. The cleaning-cycle selector switch is moved to setting No. 3, processing-line cleaning cycle, and its position switch is moved to the "on" setting.

When the start button is depressed, current flows through the contact points in relay No. 3 to each of the motors on cam timers Nos. 5, 6, and 7. After the cam which controls microswitch CT-5-1 rotates several degrees, the microswitch closes and assumes control of the motors on the three cam timers.

At the beginning of the processing-line cleaning cycle, microswitch CT-5-2 closes and energizes the rinse-tank solution makeup unit, which fills the tank with water. Microswitch CT-5-5 closes, energizing the rinse-tank temperature control unit that controls the heating of the water in the tank. About 1 minute after the cycle has started, microswitches CT-5-4, CT-5-7, and CT-6-1 close, energizing the alkali-tank solution makeup unit, the alkali-tank temperature control unit, and the alkaline detergent feeder unit, respectively.

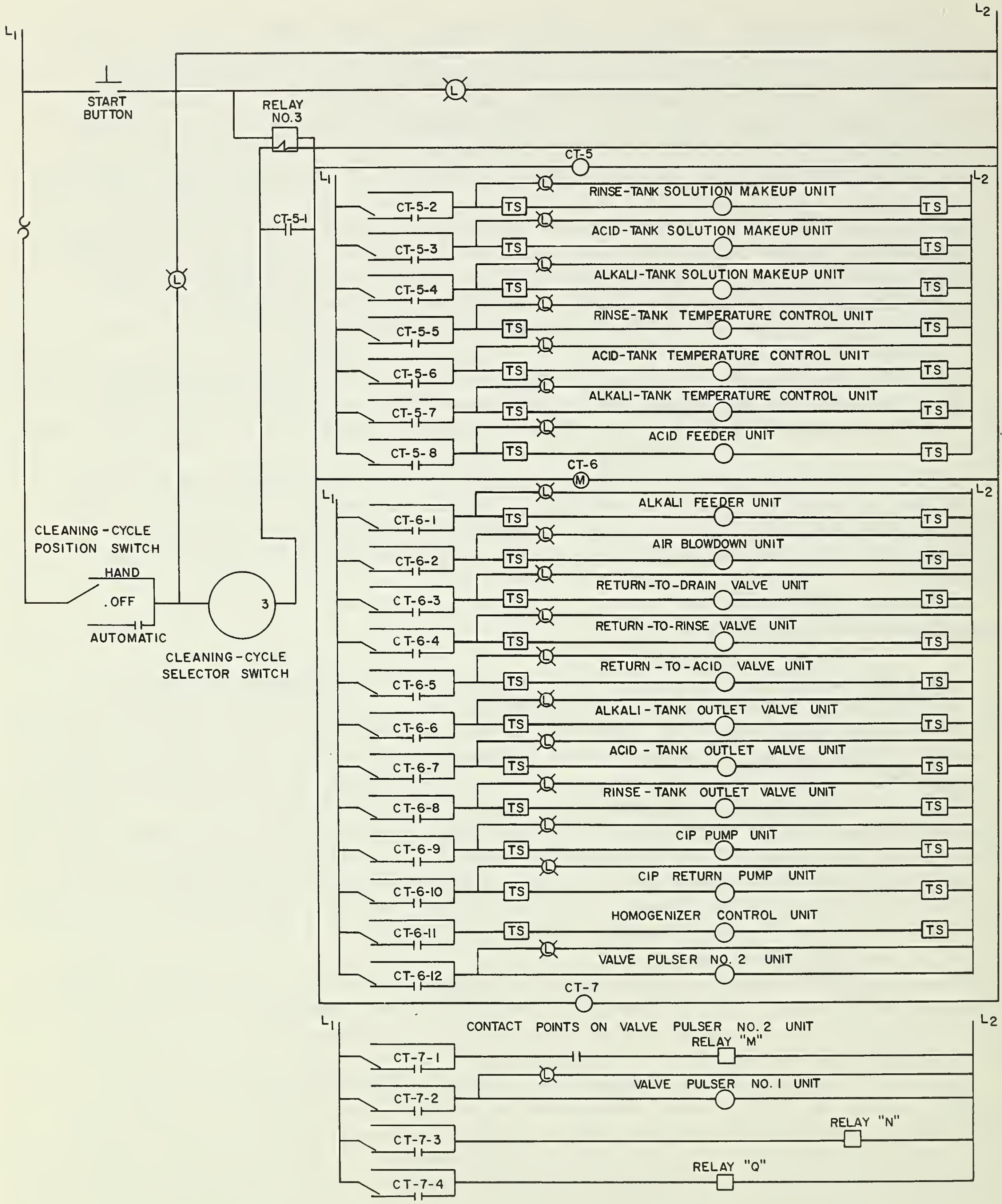

Figure 29.--Wiring diagram for the processing-line cleaning cycle.

Several seconds after the cycle has been started, microswitches CT-7-1 and CT-7-3 close, energizing relays "M" and "N," respectively (fig. 29). The closing of contact points in relay "M" allows the appropriate valves in front of the raw milk tanks to assume positions that will direct the flow of cleaning solution into the processing line. The closing of contact points in relay "N" positions the valves in front of the pasteurized milk tanks so that the flow of cleaning solution is directed through the lines and into pasteurized milk tank No. 4.

Next, microswitch CT-6-3 closes, energizing the return-to-drain valve unit. Then microswitch CT-7-4 closes and energizes relay "Q," which starts booster pumps Nos. 1 and 2 and opens valve units Nos. 6 and 7. Microswitch CT-6-10 closes, starting the CIP return pump. Microswitches CT-7-1, CT-7-3, CT-7-4, and CT-6-10 remain closed during the cleaning cycle.

The prerinse phase is started when microswitch CT-6-8 closes, energizing the rinse-tank outlet valve unit that opens the outlet valve on the rinse tank. Next, microswitches CT-5-2 and CT-5-5 open, de-energizing the rinse-tank solution makeup unit and the rinse-tank temperature control unit, respectively. Then microswitch CT-6-9 closes, starting the CIP pump. After the CIP pump has operated for approximately 2 minutes, it is stopped by the opening of CT-6-9. The first rinse water through the system flushes the lines and equipment. After 2 minutes this microswitch again closes, starting the CIP pump.

Approximately 2 minutes before the end of the rinse phase, microswitches CT-5-3, CT-5-6, and CT-5-8 close, energizing the acid-tank solution makeup unit, the acid-tank temperature control unit, and the acid feeder unit, respectively.

About 6 minutes after the beginning of the cycle, microswitch CT-6-8 opens and de-energizes the rinse-tank outlet valve unit; microswitch CT-6-9 then opens, stopping the CIP pump. Booster pumps Nos. 1 and 2 and the CIP return pump continue to operate, circulating the rinse water through the processing line and back to the CIP tank assembly where the water is directed to the drain. During these processes, microswitch CT-5-2 closes, energizing the rinse-tank solution makeup unit.

The alkaline cleaning phase starts when microswitch CT-6-6 closes, energizing the alkali-tank outlet valve unit and microswitch CT-5-4 opens, de-energizing the alkali-tank solution makeup unit. Next, microswitch CT-6-9 closes, starting the CIP pump. After the rinse water has been flushed from the system, microswitch CT-6-3 opens, de-energizing the return-to-drain valve unit, allowing the alkaline cleaning solution to return to the alkali tank.

The CIP pump is stopped and started twice during the alkaline cleaning phase to allow time for the alkaline cleaning solution to be returned to the tank. Two minutes after the start of this phase, microswitch CT-7-2 closes for approximately 2 minutes and energizes valve pulser No. 1, which pulses the valves in front of the raw milk tanks. After the valves have been pulsed several times, microswitch CT-6-11 closes, causing the homogenizer to start. The homogenizer circuit can be energized only by the cam timer. The homogenizer runs for several minutes and is then stopped by the opening of microswitch CT-6-11. Two minutes before the end of the alkaline cleaning phase, microswitch CT-6-12 closes. This closure energizes valve pulser No. 2, which pulses the valves in front of the pasteurized milk tanks during the last part of this phase and the first part of the acid cleaning phase.

Two minutes before the alkaline cleaning phase is completed, microswitch CT-6-3 closes, energizing the return-to-drain valve unit, and microswitches CT-5-7 and CT-6-1 open, de-energizing the alkali-tank temperature control unit

and the alkali feeder unit, respectively. At the end of this cycle, microswitch CT-6-6 opens, de-energizing the alkali-tank outlet valve unit; next, microswitch CT-6-9 opens, stopping the CIP pump. Microswitch CT-5-4 closes, energizing the alkali-tank solution makeup unit. The air blowdown unit is then energized by the closing of microswitch CT-6-2 for about 25 seconds.

The acid cleaning phase starts when microswitch CT-5-3 opens, de-energizing the acid-tank solution makeup unit, and microswitch CT-6-7 closes and energizes the acid-tank outlet valve unit. Microswitch CT-6-9 then closes, starting the CIP pump. The CIP pump is started and stopped twice during this phase. Microswitch CT-6-3, which controls the return-to-drain valve unit, remains closed for 2 minutes after the CIP pump starts. The closure of this microswitch keeps the return-to-drain valve open and diverts the acid cleaning solution, which has been diluted with the alkaline cleaning solution, to the drain. Microswitch CT-6-5 closes, energizing the return-to-acid-tank valve unit, before microswitch CT-6-3 opens and de-energizes the return-to-drain valve unit. Next, microswitch CT-6-12 opens, de-energizing valve pulser No. 2. By closing for 2 minutes, microswitch CT-6-11 causes the homogenizer to run while the acid solution is being circulated through the lines.

Late in the acid cleaning phase, microswitch CT-7-2 is energized for 2 minutes, causing the valves in front of the raw milk tanks to be pulsed.

Two minutes before the end of the acid phase, microswitch CT-6-3 closes, energizing the return-to-drain valve unit, and microswitches CT-6-5, CT-5-6, and CT-5-8 open, de-energizing the return-to-acid valve unit, the acid-tank temperature control unit, and the acid feeder unit, respectively. When the acid tank is empty, microswitch CT-6-7 opens, thus de-energizing the acid-tank outlet valve unit. Microswitch CT-6-9 then opens, stopping the CIP pump. Next, microswitch CT-6-2 closes for about 25 seconds and causes the air blowdown unit to be energized. After the CIP pump has stopped, microswitch CT-5-3 closes, energizing the acid-tank solution makeup unit.

The postrinse phase starts when microswitch CT-6-8 closes and energizes the rinse-tank outlet valve unit before microswitch CT-6-9 closes and starts the CIP pump. During the postrinse, the CIP pump is started and stopped twice. Microswitch CT-5-2, which controls the rinse-tank solution makeup unit, remains closed during this phase to insure an adequate supply of cold rinse water. After the processing line has been flushed with rinse water, microswitch CT-6-4 closes for the remainder of the phase, energizing the return-to-rinse valve unit, and microswitch CT-6-3 opens, de-energizing the return-to-drain valve unit. Microswitch CT-6-11 closes and opens twice during the postrinse phase, causing the homogenizer to run so it can be rinsed and cooled. During the postrinse phase, microswitches CT-7-2 and CT-6-12 are energized for several seconds, causing valve pulsers Nos. 1 and 2 to activate the appropriate valves.

At the end of the postrinse phase, microswitches CT-6-8 and CT-6-9 open, de-energizing the rinse-tank outlet valve unit and the CIP pump circuit, respectively. Next, microswitch CT-6-2 closes, energizing the air blowdown valve for about 25 seconds.

Just before the cleaning cycle is completed, microswitches CT-7-4, CT-6-10, CT-7-1, and CT-7-3 open and de-energize relay "Q." This process causes booster pumps Nos. 1 and 2 and the CIP return pump to stop and the valves in front of the raw and pasteurized milk tanks to close. Microswitch CT-6-4 opens, de-energizing the return-to-rinse valve unit. The solution makeup units--rinse, alkaline, and acid--are de-energized by the opening of microswitches CT-5-2, CT-5-3, and CT-5-4, respectively.

Microswitch CT-5-1 opens, breaking the circuit to the motors on the three cam timers that control the cycle. The indicator light for the equipment-to-be-cleaned selector switch goes off, indicating that the cleaning system has shut off automatically. However, the indicator light for the cleaning-cycle selector switch remains on until manually turned off.

The processing-line cleaning cycle has been completed automatically.

COST ANALYSIS

Cost for Equipment

The equipment requirements and costs for the CIP system are as follows:

Quantity	Unit	Cost
1	Solution supply tank assembly (three compartment)-------	$ 1,600.00
1	Main control panel (one-half cost allocated to CIP cleaning system)-------------------------------------	300.00
3	Shutoff valves @ $225 each------------------------------	675.00
3	Divert valves @ $260 each-------------------------------	780.00
1	CIP pump unit---	550.00
1	CIP return pump unit------------------------------------	400.00
1	Alkali feeder---	150.00
1	Acid feeder---	225.00
1	Chlorine feeder---	200.00
3	Temperature controls @ $180 each------------------------	540.00
--	Electrical controls for panel (includes relays, cam timers, and so forth)--------------------------------	1,000.00
3	Water or solution makeup units @ $90 each---------------	270.00
2	Valve pulsers @ $50 each--------------------------------	100.00
1	Auxiliary control panel---------------------------------	100.00
--	Piping and fittings for CIP lines-----------------------	300.00
	Total cost of equipment (includes freight)---------	$ 7,190.00
	Estimated cost cf installation--------------------	3,000.00
	Total cost of equipment and installation-----------	$10,190.00

Fixed Cost

Depreciation (based on average life of 12 years)3/	
0.0833 x $10,190--	$ 848.83
Taxes and insurance (based on 4 percent of initial investment)	
0.04 x $10,190--	407.60
Interest (based on 6 percent of average investment)	
0.06 x $\left(\frac{\$10,190}{2}\right)$---	305.70
Total fixed cost per year--------------------------------	$ 1,562.13
Total fixed cost per week--------------------------------	$ 30.04

3/ U.S. Internal Revenue Service. Depreciation Guidelines and Rules. IRS Revenue Procedure 456, 92 pp. 1964.

Variable Cost
(Electric power and maintenance for cleaning system)

CIP pump ($7\frac{1}{2}$ hp. @ 0.8 efficiency x 746 watts/hp. x \$0.02 kw.-hr.)	\$ 0.14/hour
CIP return pump (3 hp. @ 0.8 efficiency x 746 watts/hp. x \$0.02 kw.-hr.)	.06/hour
Control panel 500 watts (estimated) x \$0.02 kw.-hr.	.01/hour
Maintenance (estimated)	.10/hour
Total variable cost	\$ 0.31/hour

Estimated cost of the CIP cleaning system as listed is \$30.04 per week plus \$0.31 per hour of operation. Since the cleaning system is operated 10 hours per week (2 hours per day, 5 days per week), the total cost of the system is \$33.14 per week.

Figure 30 gives a comparison of time savings required if various wage rates are to pay for the CIP cleaning system as listed. If the increased investment is to be justified, the CIP cleaning system must release to other essential jobs a minimum of 8.28 hours of cleaning labor per week, presuming the standard wage rate is \$4 per hour.

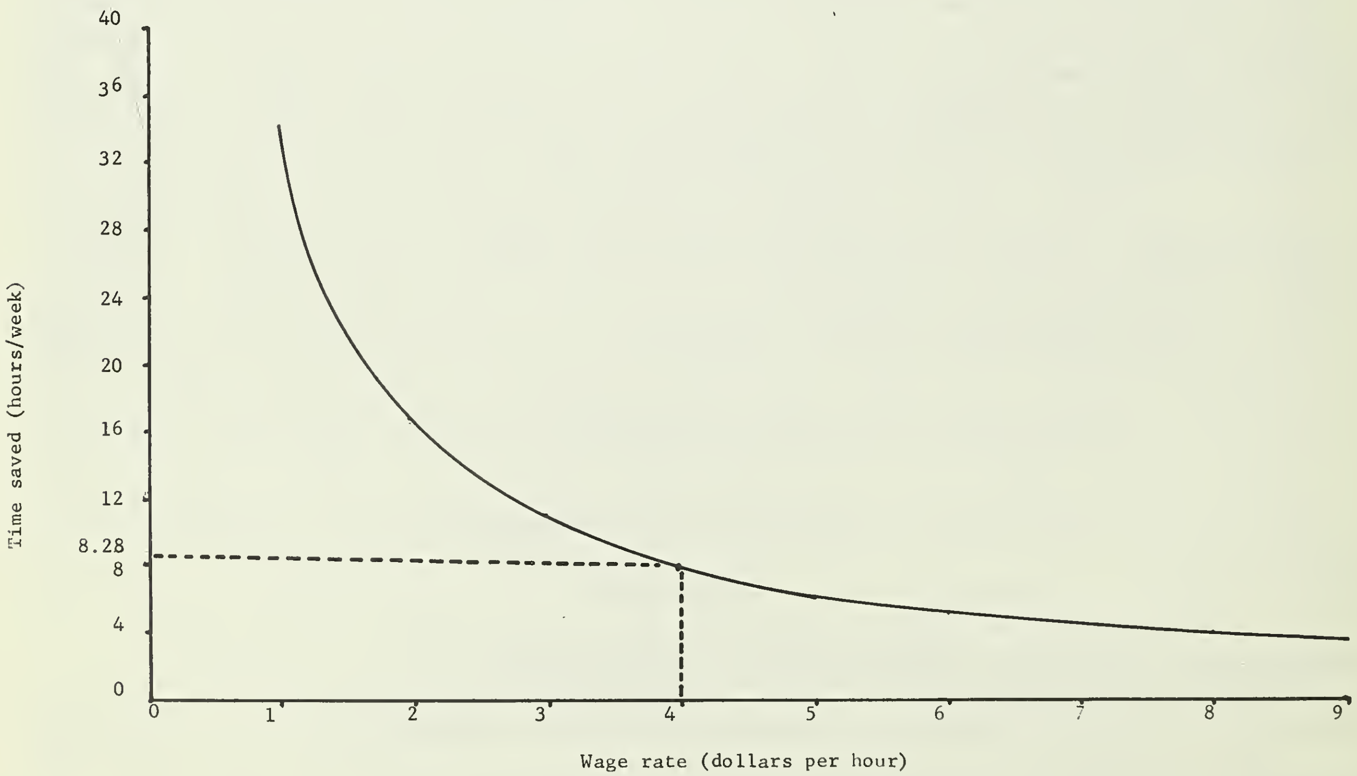

Figure 30.--Time savings required for various wage rates to justify CIP cleaning system.

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